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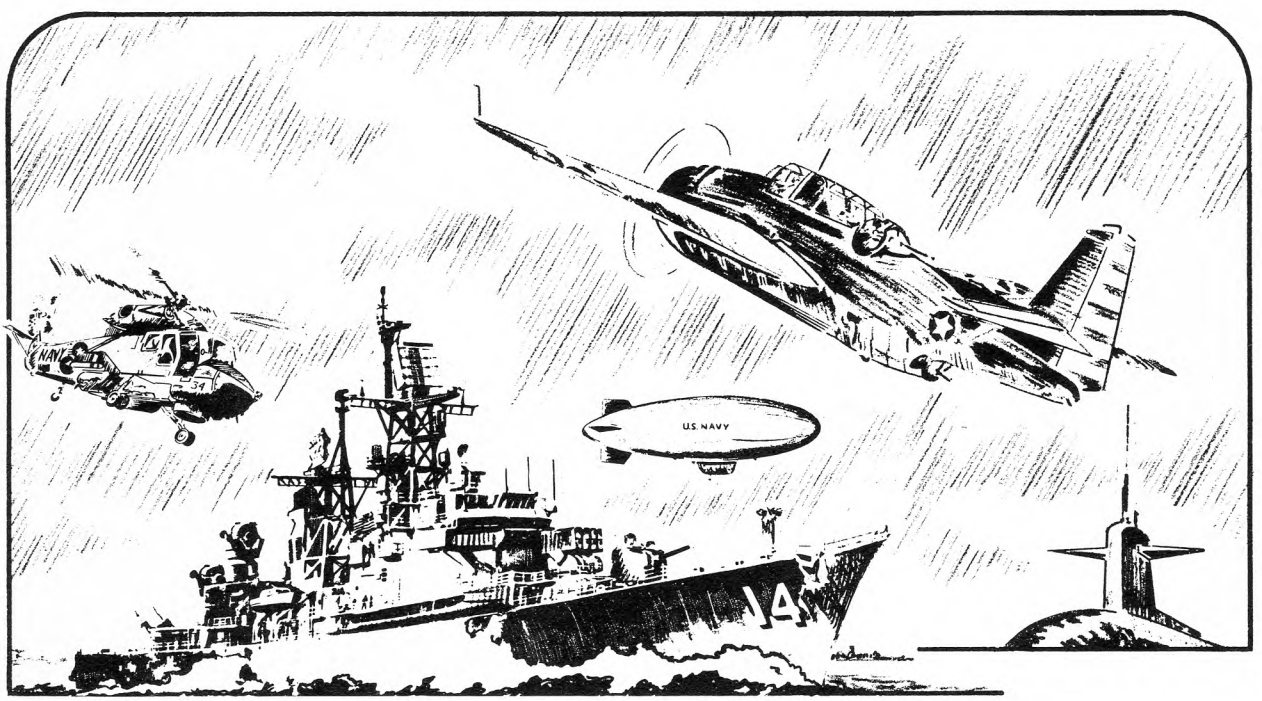
A Brief History of U.S. Navy Torpedo Development

E. W Jolie
Weapon Systems Department



Naval Underwater Systems Center
Newport Laboratory

PREFACE

In the preparation of this report, the author has relied on the archival holdings of the Naval Underwater Systems Center and resource material made available by current NUSC staff members. Particular thanks are due to Mr. A. E. Burke of the Weapon Systems Staff, Mr. R. R. Corridon of the Technical Shops Department, and Mr. A. J. Turner of the Weapon Systems Department; and the efforts of Ms. P. A. Ellis, Mr. M. A. deSa, and Mr. R. A. Thibodeau of the Information Services Department in editing and illustrating this report are gratefully acknowledged. Other persons too numerous to mention have also provided both information and support in the preparation of this document.

This report is presented with the awareness that parts of the story could be treated only as fully as the resource material permitted. Suggestions for additions, corrections, or other improvements will be welcomed at any time.

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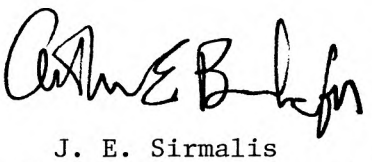

J. E. Sirmalis
Head, Weapon Systems Department

The author of this report is located at the Newport Laboratory, Naval Underwater Systems Center, Newport, Rhode Island 02840.

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This report covers the growth/development of the "auto-mobile" or self-propelled torpedo in the U.S. Navy from torpedo inception in Europe by Robert Whitehead in 1866 up to and including Torpedo Mk 48 of 1978. Part I is a narrative of the historical aspects of the evolution, while part II contains illustrations and characteristics of each of the torpedoes that was in development or is/was in service use over the 112-year period.

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FOREWORD

This document is an attempt to present in an organized way, and thereby preserve, what is known of the history of torpedo development while the resources are still available. The last known attempt at a comprehensive treatment of this special weapon form in the United States was the "History of the U.S. Naval Torpedo Station." Compiled around 1946 and covering the time period from 1869 through 1945, the document (by subject and by design) presents a parochial view, and its seven volumes are concerned primarily with the "steam" torpedo and the Navy in-house effort in the development of an electric torpedo. A limited but outstanding history of the early passive acoustic homing torpedoes is a volume by Albers.[1]

This history is based for the most part on source material from the archives of the Naval Underwater Systems Center, Newport Laboratory, Newport, Rhode Island (successor to the U.S. Naval Torpedo Station) and the files of its current staff. The limiting factor on the depth of treatment of some torpedoes is the availability of information; the darkest spot is the era between 1900 and 1930. Since a main objective was to present the information in an unclassified document, security classification limited the details and discussion of the more current torpedoes.

From the days of its inception by Howell and Whitehead, the torpedo has been a keystone in naval tactical development. The destroyer and submarine came into being as a result of the need for a launch platform for the torpedo. The torpedo's awesome potential was demonstrated on a large scale in World War I when the German U-boats sank 5400 Allied ships with a total displacement of 11,189,000 tons.

In spite of their problems and seemingly endless adverse publicity by critics, the U.S. Navy submarine torpedoes in World War II were credited with sinking 1314 Japanese ships for a total of 5,100,000 tons accounting for 55 percent of all World War II Japanese ship losses. Thus, the torpedo, which in the 1880's "stirred naval tacticians more profoundly than any weapon produced,"[2] demonstrated its tremendous effectiveness in a time of great need.

This document is divided into two sections. Part 1 is a brief narrative on the history of the various torpedoes. Part 2 presents the physical and performance characteristics of the individual torpedoes as well as a simple illustration of the shape of the weapon. A chronology of significant events relating to the development of modern torpedoes is given as appendix A, while a list of the former and current identities of various developers and producers of the modern torpedo is presented as appendix B.

PART 1

HISTORICAL BACKGROUND

HISTORY OF EARLY TORPEDOES (1800-1870)

THE GOOD OLD DAYS

The word "torpedo" is generally believed to have been first used by Robert Fulton around 1800 to describe a device with an enclosed mass of gunpowder which was to be exploded beneath enemy ships. The word may have been chosen due to the similarity in the way in which the device and the torpedo fish both communicated shock, or simply because detonation of the charge rendered fish torpid.

In any case, the word torpedo was generally applied to all underwater explosive devices through most of the nineteenth century. David Bushnell, Robert Fulton, Samuel Colt, and other early inventors were concerned with stationary torpedoes or what are called mines today. The earliest recorded use of a torpedo was in 1801 when Robert Fulton sank a small ship using a submarine mine with an explosive charge of 20 pounds of gunpowder at Brest, France.

Stationary torpedoes were first used on a large scale by the Russian government during the Crimean War (1854-1856). They were used as part of the defense of Sebastapol, at the entrance to the Sea of Azov in the Black Sea, and at Cronstadt and Sweaborg in the Baltic Sea. In the Baltic, torpedoes were exploded under four English ships near Cronstadt. None were destroyed, but all were damaged to some degree.

Various types of torpedoes were employed during the Civil War with the Confederate Navy enjoying the greater success. Twenty-two Union ships were sunk and twelve were damaged by Confederate torpedoes, while six Confederate ships were destroyed by Union Navy torpedoes.

The idea of providing mobility to the torpedo, thereby turning it into an "offensive" rather than "defensive" weapon, is generally credited to Fulton, who proposed using a boom-mounted explosive charge in the early nineteenth century. The boom or spar-mounted configuration was employed by both the Confederate and Union Navies during the Civil War. The most notable use of the spar torpedo was the sinking of the Confederate ram ALBEMARLE by Lt. W. B. Cushing, U.S.N., at Plymouth, N.C. in October of 1864.

Another type of mobile torpedo adopted by most navies in the years from 1870 to 1880 was the towed torpedo. An explosive charge was contained in a case that had a fixed rudder (figures 1 and 2) so that it could be towed off the ship's stern or beam. When towed from abeam, the tow line assumed an angle of about 45° with the ship's centerline when under way. When the torpedo contacted an enemy ship the charge was detonated either electrically or by impact.

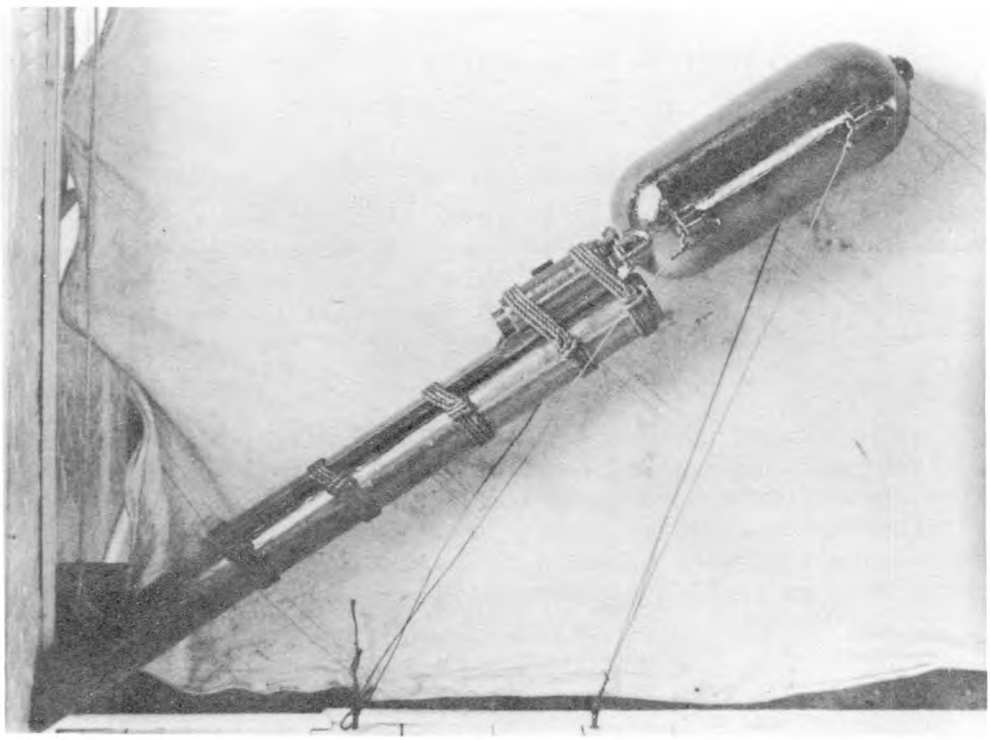


Figure 1. Explosive Charge Lashed to Boom of Spar Torpedo

Figure 2. Spar Torpedo Rigged for Test from Bow of Steam Launch

ORIGIN OF THE WHITEHEAD TORPEDO

About the middle of the nineteenth century, an officer of the Austrian Marine Artillery conceived the idea of employing a small boat carrying a large charge of explosives, powered by a steam or an air engine and remotely steered by cables to be used against enemy ships. Upon his death, before he had perfected his invention or made it public, the papers of this anonymous officer came into the possession of Capt. Giovanni Luppis of the Austrian Navy. Impressed with the potential of the idea, Luppis had a model of the boat built which was powered by a spring-driven clockwork mechanism and steered remotely by cables. Not satisfied with the device, in 1864 Luppis turned to Robert Whitehead, an Englishman. Whitehead was then manager of Stabilimento Tecnico Fiumano, a factory in Fiume, Austria (now Rijeka, Yugoslavia) on the Adriatic Sea. Whitehead was also impressed with the potential of such a weapon and became determined to build an automatic torpedo that could run at a given depth below the surface for a reasonable distance.

In October 1866, the first experimental model was ready. As designed by Whitehead, the model was driven by a two-cylinder, reciprocating, compressed-air engine, which gave the torpedo a speed of 6-1/2 knots for a distance (range) of 200 yards. Compressed air for propulsion was stored in a section of the torpedo known then, and still known now, as the air flask at a pressure of 350 psi. Figure 3 shows the probable form of this torpedo.

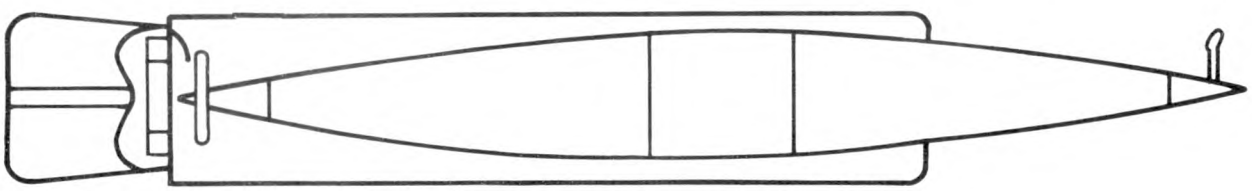


Figure 3. Probable Form of Whitehead Torpedo (1868)

Austria, the first government to show interest in the invention, purchased and conducted experiments with the torpedo during 1867-1869. As a result, in 1869 Austria purchased the manufacturing rights from Whitehead for an unknown price, but permitted Whitehead to sell his torpedoes to other governments.

Contemporary Russian literature on torpedoes states that the first self-propelled mine (torpedo) was developed by the Russian inventor I. F. Aleksandrovskiy in 1865. In spite of successful tests of the Aleksandrovskiy torpedo, the Russian Naval Ministry preferred to buy the torpedoes designed by Whitehead which, it is claimed, were no better in quality or characteristics than the Aleksandorovskiy torpedo.

THE WHITEHEAD TORPEDO IN THE WORLD MARKET

Whitehead offered his torpedoes for sale to the navies of the world. In 1868, he offered two models:

1. Length, 11 feet 7 inches; diameter, 14 inches; weight, 346 pounds; explosive charge, 40 pounds guncotton.

2. Length 14 feet; diameter, 16 inches; weight 650 pounds; explosive charge, 60 pounds guncotton.

Performance of the two models was about the same: 8-10 knots with a range of 200 yards. The offering price of these torpedoes was $600 for the smaller version and $1000 for the larger model.

The Royal Navy (U.K.) became interested in the Whitehead Torpedo following a successful warshot demonstration in home waters in 1869 and received their first delivery in 1870. In 1871, the Admiralty bought manufacturing rights, and production was started at the Royal Laboratories at Woolrich, England. Within a short time, the British were manufacturing their own version of the Whitehead Torpedo which was known as the "Woolrich" or "Royal Laboratory" pattern.

The French, German, Italian, Russian, and Chinese Navies followed the Royal Navy in the purchase of the Whitehead Torpedo and soon Whitehead was exporting his torpedo around the world. By 1877, the Whitehead Torpedo was attaining speeds of 18 mph for ranges of 2500 feet (830 yards) and/or 22 mph for 600 feet (200 yards). Air flask pressure also had been increased to approximately 1100 psi.

By 1880 nearly 1500 Whitehead Torpedoes had been sold to the following countries:

> Great Britain, 254, Germany, 203; France, 218; Austria, 100; Italy, 70; Russia, 250; Argentina, 40; Belgium, 40; Denmark, 83; Greece, 70; Portugal, 50; Chile, 26; Norway, 26; and Sweden, 26.

Whitehead had achieved instant success with a novel weapon. The first experimental torpedo worked well and was being mass produced for export within four years: an enviable achievement for any new product development!

THE SCHWARTZKOPFF TORPEDO

In 1873, the firm of L. Schwartzkopff, later known as Berliner Maschineubau A. G. (Berlin Machine Building Stock Co.), began manufacturing torpedoes based on the Whitehead design. Characteristics of the Schwartzkopff torpedo were:

Length - 14 feet 9 inches,
Diameter - 14 inches,
Speed - 23-25 knots for 220 yards, 22-23 knots for 440 yards,

Weight - 616 pounds,
Flask pressure - 1500 psi,
Explosive charge - 44 pounds guncotton.

Schwartzkopff was permitted to sell this torpedo to such countries as were designated by the German government: Russia, Japan, and Spain. Since the Schwartzkopff Torpedo was manufactured entirely of bronze rather than steel as was the Whitehead, corrosion resistance was one of the main selling points of this torpedo.

U.S. NAVAL TORPEDO STATION, NEWPORT, R.I.

The U.S. Naval Torpedo Station (USNTS), Newport, R.I., was established in 1869 as a U.S. Navy experimental station for the development of torpedoes and torpedo equipment, explosives, and electrical equipment. The first Commanding Officer was LCDR E. O. Matthews, U.S.N. Located on Goat Island in Newport Harbor, the torpedo station site had been used as a fort by the town, colony, state, and finally the U.S. Government since its purchase in 1676 by the town of Newport from Benedict Arnold (who had purchased it in 1658 from Cachanaquoant, Chief Sachem of the Narragansett Bay Indians). The island was deeded to the U.S. Government in 1799 by the town of Newport for $1500. The name of the fort on Goat Island changed with the political winds and when occupation began by the Torpedo Station, it was known as Fort Wolcott.

In 1869, the occupation of Goat Island by the Navy was authorized by the Secretary of War. Initially, the Torpedo Station had three civilian employees and the facilities consisted of the wooden buildings that had been erected and then abandoned by the former occupants. Initial efforts were devoted to stationary torpedoes (moored mines) and the spar torpedo (a boom-mounted contact explosive charge).

THE U.S. NAVY FISH TORPEDO

Shortly after its establishment, the Torpedo Station at Newport was given the task of building a "Fish" Torpedo, similar to the Whitehead Torpedo. The Fish Torpedo was to be designed to meet two requirements:

1. To go underwater for a considerable distance at a fair rate of speed, and

2. To make a straight course and maintain constant immersion, whether started on the surface of the water or at any point below it.

A torpedo then was built which had the following characteristics:

Shape - Fusiform,
Radius of the curves - 66 feet,
Diameter - 14 inches,
Length - 12-1/2 feet,
Total weight - 480 pounds,

Explosive - 70-90 pounds guncotton,
Speed - 6-8 knots,
Range - 300-400 yards.

The torpedo had a two-cylinder reciprocating engine, operated by compressed air, which drove a 1-foot-diameter, four-bladed propeller. A hydrostatic depth control mechanism was also used. The first torpedo trial was in 1871. The torpedo did run, but difficulty was encountered in obtaining a water-tight hull and an air-tight air flask. Azimuth control was a problem although the depth mechanism worked well. Figure 4 is an actual photograph of the Fish Torpedo.

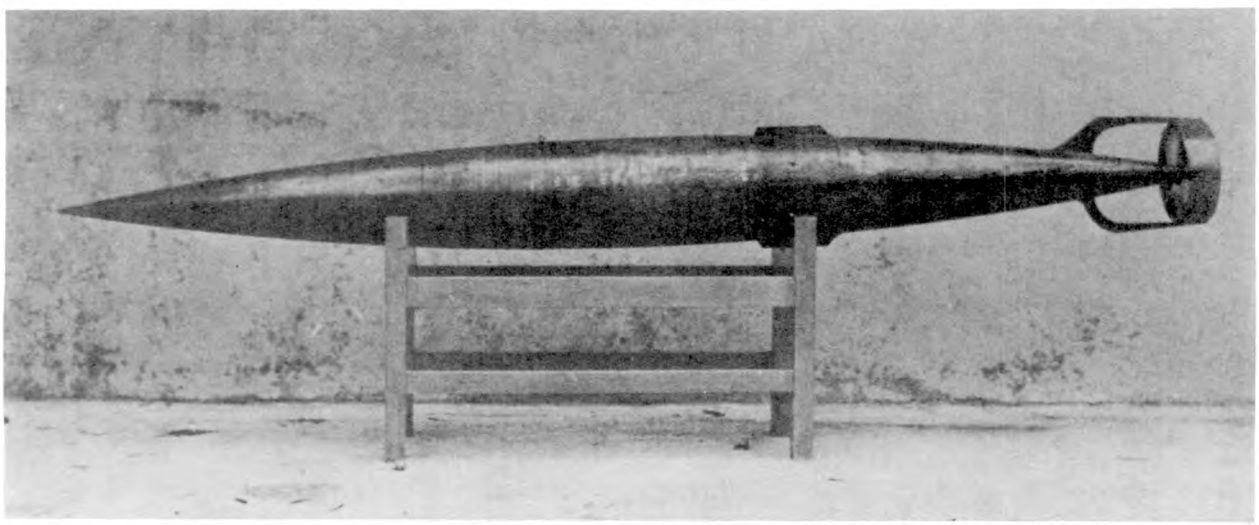


Figure 4. Newport's Auto-Mobile "Fish" Torpedo (1871)

Accounts indicate that an attempt was made to overcome the problems encountered in the first test by modifying the torpedo. The modifications consisted of a new air flask cast in one piece and a new engine.

The second version of the torpedo was given captive in-water trials alongside the dock in 1872. It was estimated to have achieved a speed of 8-1/2 knots and would have run 4000 feet (1300 yards), which was comparable to the Whitehead Torpedo of that time. A proposal for the Fish Torpedo was submitted to the Bureau of Ordnance (BuOrd) in 1874, but beyond that there is no record of any further effort on the U.S. Navy Fish Torpedo.

THE TORPEDO TAKES A NEW SHAPE

Early torpedoes were fusiform or spindle shaped with no straight cylindrical section between the nose and the tail as shown in figures 3 and 4. The shape was based on the premise that the long tapered nose would cut or part the water, yielding better hydrodynamic performance.

In 1883, a committee was appointed in the United Kingdom to study various aspects of torpedo design. A hydrodynamicist of that day, Dr. R. E. Froude, stated that the blunt nose offered no speed disadvantage and would permit more explosive to be carried.

Comparative tests were conducted by the committee using a Whitehead Torpedo and a Royal Laboratories torpedo, each of which was fitted with both a pointed and a blunt nose. The tests showed that the blunt nose offered a full knot speed advantage over the pointed nose. This meant that more volume could be devoted to carrying explosive and air for propulsion without sacrificing speed performance. The volume gained was quite significant, bearing in mind that the nose shape in question extended from the middle of the torpedo's length to the tip of the nose. The ultimate in blunt nose design during this period appeared about 1909 with the American hemispherical heads.

U.S. REACTION TO THE WHITEHEAD TORPEDO

In spite of the spectacular achievement of the Whitehead Torpedo, two offers to sell the rights to the U.S. Navy, in 1869 for $75,000, and again in 1873 for $40,000, were not accepted. An employee of the Woolrich Laboratory was also willing to turn over plans and specifications for the torpedo in return for employment at the USNTS in Newport. Although the record indicates that the Navy declined the sub-rosa offer, a set of plans was obtained and turned over to Commodore Jeffers, then Chief of BuOrd. The plans were not exploited, but were the subject of a lengthy exchange and quite probably legal proceedings between Commodore Jeffers and Robert Lines, Whitehead's U.S. agent, as reported in the press in the spring of 1881.

A summary reaction to the Whitehead Torpedo was that it "stirred naval tacticians more profoundly than any weapon ever produced"[2] by its tremendous potential; but the Whitehead Torpedo seems to have inspired a contrary reaction among U.S. Navy tacticians. A paper on "movable torpedoes" published in 1873 states, "Our conclusion is that the Whitehead-Luppis Torpedo is not adaptable to the combat of vessels on the high seas, but that it can be advantageously employed in the defense of ports and the attack of vessels surprised at anchor."[3] The Navy consensus of the day was that the Whitehead Torpedo was too delicate, too complex, and too "secret."

In fairness, it must be said that the Whitehead Torpedo also had other critics. Defects of the Whitehead Torpedo as enumerated in an 1889 British publication, were:

> 1. Inefficiency due to the small charge carried, which is not sufficient to destroy the hulls of vessels like modern ironclads that are divided into numerous water-tight compartments.

2. Uncertainty as to Accuracy. - For, although a vessel can generally be hit up to a range of 300 yards, this cannot be depended upon, the course of a Whitehead occasionally being very erratic, especially with over-water discharge from the broadside of a vessel at speed. Moreover, during handling and discharge, the fins, and rudders, and other gear projecting from the body of the torpedo, are liable to derangement. Inaccuracy as to submersion is also encountered, due to imperfections in the design or manufacture of the automatic controlling gear.

3. Expense. - The manufacturing cost of one Whitehead being over 500 pounds, to which must be added the share of price first paid for the patent, and the cost of the discharging appliances.

4. Intricacy. - The torpedo containing a quantity of highly finished and complicated machinery.

5. Difficulties in Manipulation. - Great intelligence on the part of the personnel combined with a long and careful training being essential.

6. Difficulties in Maintenance. - Constant attention and care being required to keep the torpedoes and their impulse arrangements clean and efficient.

7. Loss of Control after Discharge. - Which, combined with the uncertainty as to accuracy already mentioned, increases the difficulties attending the employment of these torpedoes in fleet actions.

8. Motive Power Dangerous. - The highly compressed air having sometimes burst the torpedo. Hostile shot would increase this danger.

9. Space Occupied. - Especially when that of the appurtenances are taken into consideration.

Not only are the above defects recognized by many critics whose opinions are not to be despised, but the torpedo boats specially built to carry the Whitehead are now regarded with much less favor than formerly, owing to the physical impossibility that human beings can live on board when the boats are required to keep the sea for any length of time. Indeed, it appears that all Whitehead torpedo boats that are too large to be hoisted on board a man-of-war, and yet too small themselves to keep the sea, must be relegated to harbour or river defense.[4]

It is not too surprising, then, that during this period (1870-1880) the U.S. Navy chose to de-emphasize the "Fish" or "Auto-mobile" torpedo and content itself with further development of the spar and towing torpedoes primarily through the addition of electrical detonation features.

EARLY U.S.N. TORPEDO DEVELOPMENTS (1870-1915)

TORPEDO EXPERIMENTS IN THE U.S. (1870-1900)

Torpedo development in the United States during the period from 1870 to 1900 consisted of experimenting with many schemes. Chemical, electrical, and rocket propulsion were attempted, and surprisingly, guidance and supplying of power by means of a trailing wire was popular. The USNTS at Newport was the site of many of the experiments and tests of the devices proposed by the civilian and military inventors of the day.

This was the era of the "Lay," "Lay-Haight," "Ericsson," "Cunningham," "Sims-Edison," and "Barber" Torpedoes, to mention a few. An illustration and brief description of major characteristics of these torpedoes follows. (See figures 5 through 10.)

1. Lay Torpedo: A chemical torpedo propelled on the surface by a reciprocating engine operated by superheated carbonic acid gas. Two cables payed out from the torpedo to the controlling ship or station, controlled the stop and start mechanism, and the steering engine (1872).

2. Barber Torpedo: A submarine torpedo propelled by a rocket charge (1873).

3. Ericsson Torpedo: A torpedo with a rectangular cross section, propelled and steered by compressed air fed to it from a shore station through a rubber hose coiled within torpedo and payed out as the torpedo moved ahead; introduced concentric drive shafts (1873-1877).

4. Lay-Haight Torpedo: Three-cylinder, engine-propelled torpedo, using carbonic acid expanded in external tanks warmed by sea water (1880). Sulphuric acid and lime was used to increase speed (1883).

5. Sims-Edison Torpedo: A float-supported torpedo, electrically driven from shore generator through a cable, controlled from shore by battery-operated steering mechanism; detonated by contact or by operator (1889).

6. Cunningham Torpedo: Another rocket-propelled torpedo to be fired from submerged tubes (1893-1894).

Figure 5. Lay Torpedo

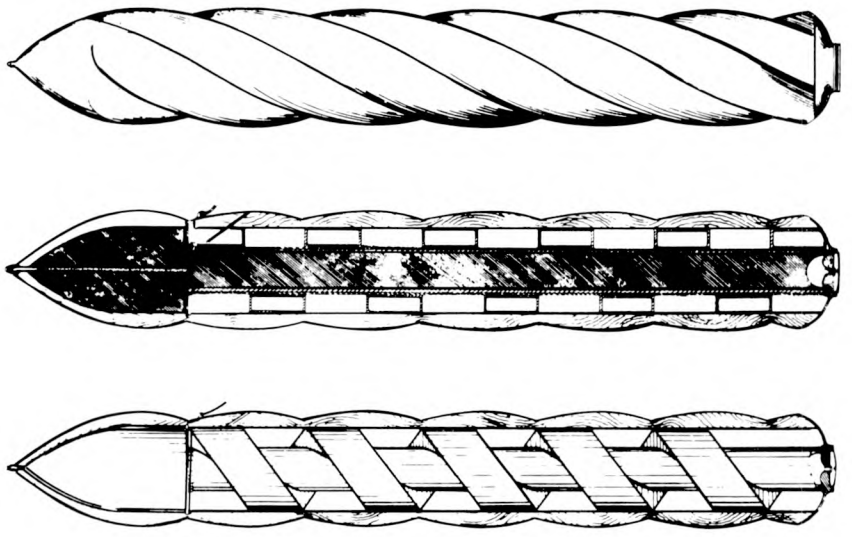


Figure 6. Barber Torpedo

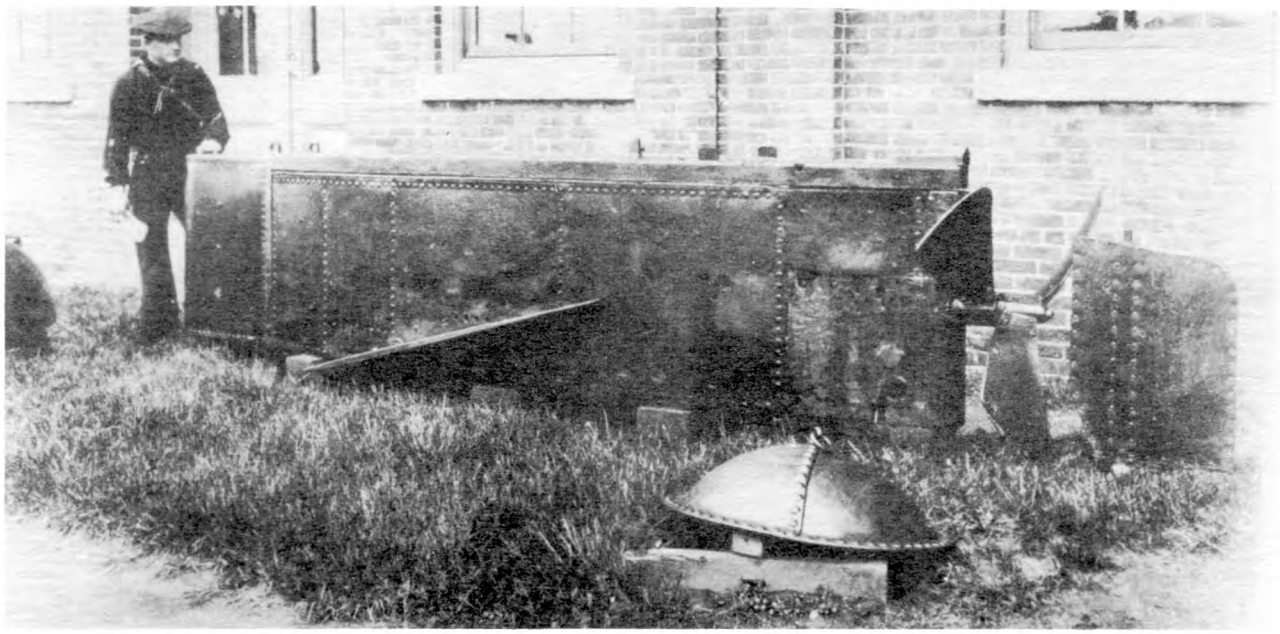


Figure 7. Ericsson Torpedo

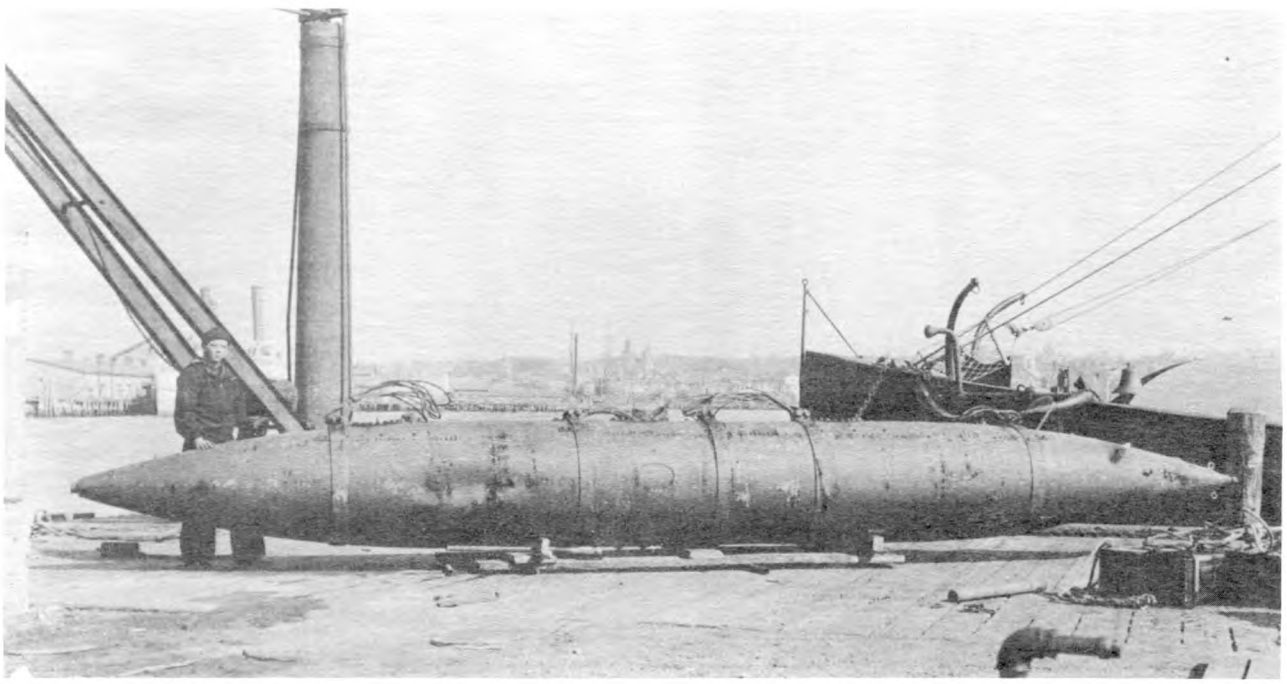


Figure 8. Lay-Haight Torpedo

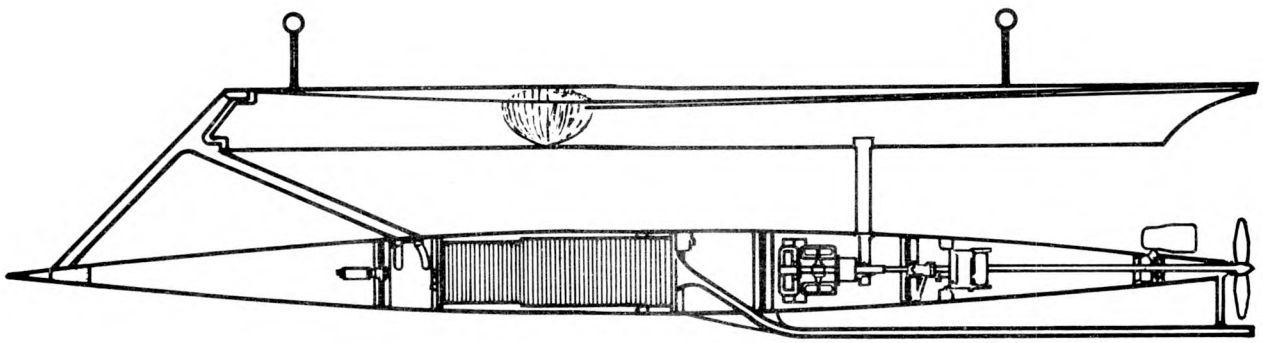


Figure 9. Sims-Edison Torpedo

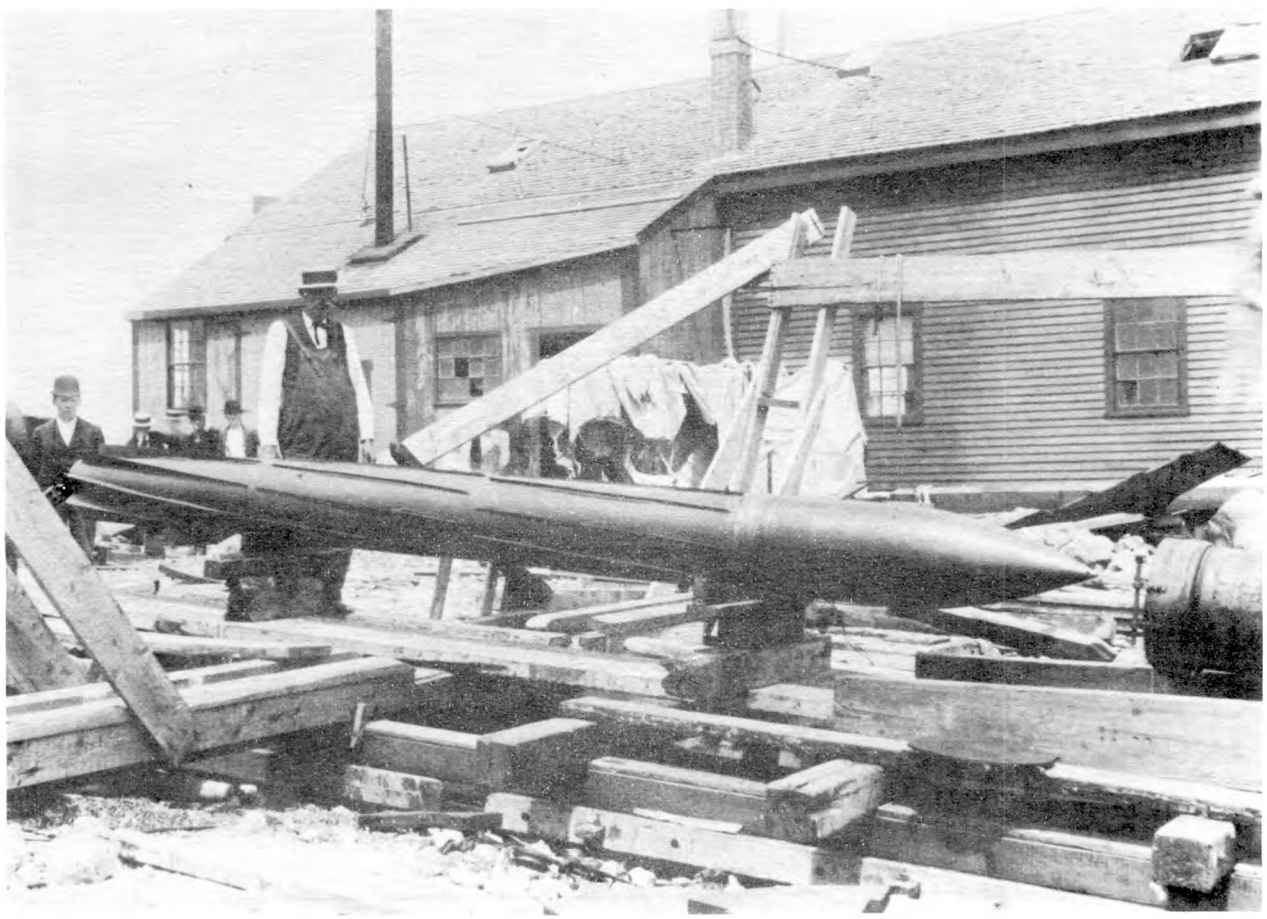


Figure 10. Cunningham Torpedo

THE HOWELL TORPEDO

The first successful U.S. torpedo development began in 1870 and was completed in 1889. Largely the work of LCDR J. A. Howell (later Rear Admiral, U.S.N.) the Howell Torpedo was driven by a 132-pound flywheel spun to 10,000 revolutions per minute prior to launch by a steam turbine mounted on the torpedo tube. Two variable pitch propellers on parallel shafts were driven through bevel gearing from the flywheel. The diminishing speed of the flywheel, in turn, was compensated for by propeller pitch to maintain a constant torpedo speed. The rotating flywheel created a gyroscopic effect. Deviations in azimuth were adjusted by a pendulum which sensed the heel of torpedo when it deviated from its course and was coupled to the rudder. This gave the torpedo good directional stability; however, the depth-keeping characteristics were not good. Despite this, the Howell Torpedo was used in service on U.S. battleships until 1898 when it was supplanted by the Whitehead Torpedo. (The Howell Torpedo is shown in figure 11.)

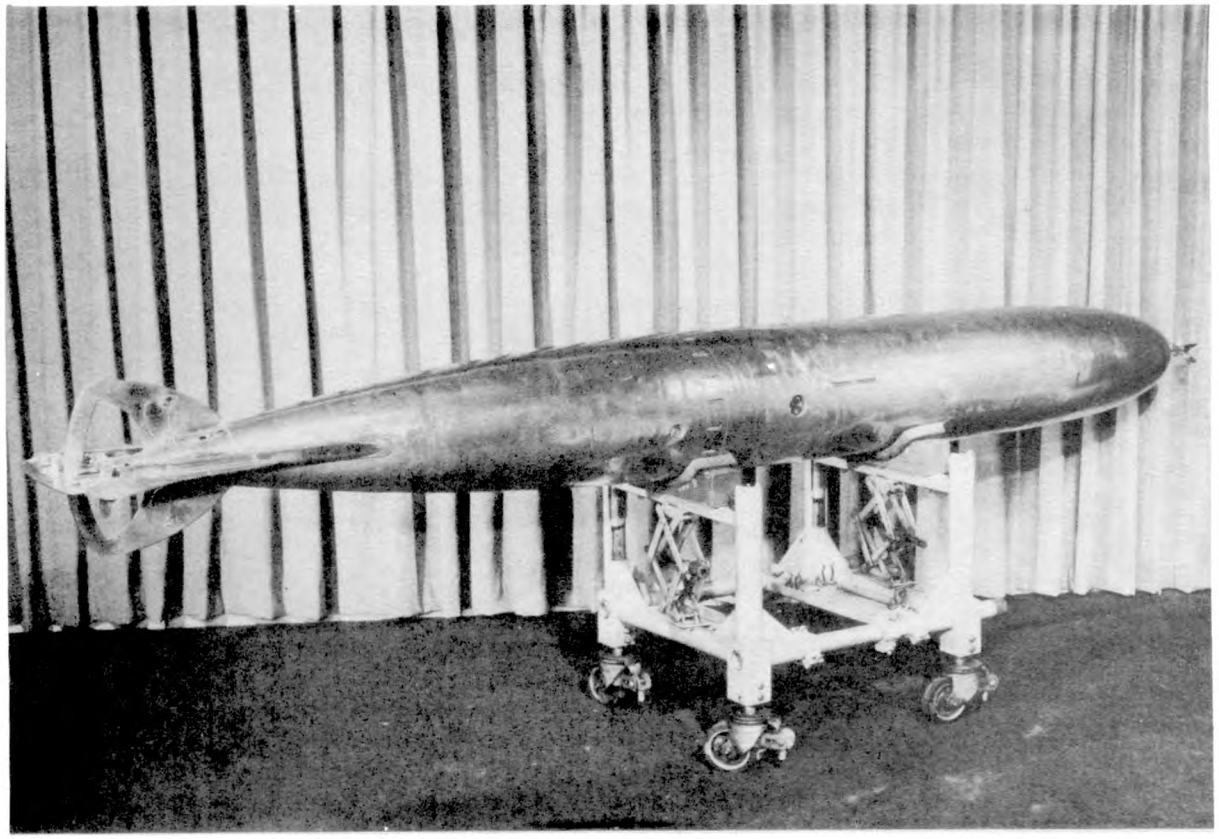


Figure 11. Howell Torpedo

Although the Howell Torpedo did not create the reaction of the Whitehead Torpedo, the following contemporary discussion is of interest.

> The objection has been raised that this torpedo "does not lie in a state of constant readiness, but has to be spun up" before it is ready to launch, but it must be noted that when the wheel has been spun up, very little power will keep it going, and therefore the torpedo can be kept in the state of "ready" from the commencement of an action until its termination, unless, in the meantime, it be discharged.
>
> Remembering the defects of the Whitehead Torpedo, which have been enumerated, it will be found that most of them have been overcome in the Howell Torpedo.
>
> Thus:
>
> 1. The inefficiency due to small charge carried has been met.
>
> 2. Also the uncertainity as to accuracy.
>
> 3. Also the great expense, for the Howell Torpedo and its appurtenances are cheaper to manufacture.
>
> 4. Also, simplicity of detail is substituted for that intricacy and delicacy of detail which in the Whitehead enlists our astonishment and admiration.
>
> 5. As regards manipulation, comparative trials are required, the advocates of the new arm being confident of the result.
>
> 6. The maintenance of the simpler apparatus must be less troublesome and costly.
>
> 7. The new arm is evidently under better self-control after discharge.
>
> 8. The danger due to the existence under fire of a chamber full of highly compressed air is absent.
>
> 9. And finally, the space occupied is less than with the Whitehead.
>
> In short, it would appear that the Howell is superior on nearly all points, and, on account of its humming sound, is inferior only as an arm for a sneak boat, or for a vessel attempting to run a blockade.
>
> The torpedo has been officially tried in the United States, and the Naval Board detailed to carry out these experiments has, it is understood, reported very favourably on the invention.

> If used for harbour defense these torpedoes might be placed in shore batteries, and their simple fittings and accessories would not be difficult to keep in order. But it would generally be preferable to mount them on some floating body and moor it under the shelter of the land or a fort in a convenient place for aiding the defence. By these means, a foe would be kept in ignorance of the position from which his vessels might be torpedoed should they attempt to force a passage.[4]

THE WHITEHEAD TORPEDO JOINS THE U.S. NAVY

Around 1891, negotiations for torpedo manufacturing rights in the United States began in earnest between the Whitehead Co. and the E. W. Bliss Co. of Brooklyn, N.Y. Favorable terms were reached and in 1892, the U.S. Navy contracted with the Bliss Co. for the manufacture of 100 Whitehead (3.55 meters by 45 centimeters) Mk 1 torpedoes at a price of $2000 each. Thus, some 26 years after the Whitehead Torpedo was introduced, U.S. experts finally got around to this tacit admission of its worth. This concession was probably inspired in part by a successful torpedo attack on 23 April 1891, against the Chilean insurgent 3500-ton battleship BLANCO ENCALADA. This ship was sunk while at anchor by a Whitehead Torpedo fired from a gun boat.

Between 1896 and 1904, the Bliss Co. manufactured approximately 300 more Whitehead-developed units of five types for the U.S. Navy. The 3.55-meter Whitehead Mk 1, Mk 2, and Mk 3 torpedoes were basically the same, differing mainly in mechanical details. The Mk 1 and Mk 2 versions were also available in the 5-meter length.

The performance of the two Whitehead Mk 1 torpedoes was the same, but the 5-meter Mk 1 used the Obry steering gear (gyro) invented by an Austrian, Ludwig Obry, for azimuth control and had the largest warhead of any torpedo of that time -- 220 pounds of wet guncotton.

In 1856, the French physicist, Leon Foucault, invented and built a laboratory model of the gyroscope as it is known today. In 1894, Obry was granted a patent for his gyro mechanism to control the torpedo in azimuth. Other similar devices were being actively pursued at the same time. In Germany, Schwartzkopff was using a device developed by Kaselowski of that company and Robert Whitehead was experimenting with the Petrovich device, developed by a Russian; both appear to have attained marginal results. Overshadowing all, there was the Howell patent of 1871 in which the use of the flywheel for directional control was a part. In 1898, Howell initiated legal proceedings against Bliss, the Whitehead U.S. licensee, because of the use of the Obry gear in Whitehead Torpedoes. However it was found that the Obry device did not infringe on the Howell patent.

Initially, the gyro was used to keep the torpedo on a course as defined by the axis of the launcher; this meant that the aiming of the torpedo had to be accomplished by maneuvering the firing ship. The installation of trainable torpedo tubes in 1893 improved the tactical flexibility. Finally, curved

fire, which used the gyro to control the torpedo on a preset course, was adopted in U.S. Navy torpedoes about 1910. First installed in the Whitehead Mk 5 torpedoes of U.S. manufacture and the Bliss-Leavitt Mk 2 torpedoes, it was intended for use from fixed tube installations. Ultimately it was applied to all straight-running torpedoes, and all torpedo tubes were provided with gyro angle setting capability.

The two Whitehead Mk 2 torpedoes had different performance characteristics; the 5-meter version had slightly better speed and nearly double the range than that of the 3.55-meter version. In a significant departure from the Mk 1, the 5-meter Mk 2 did not have a gyro for control in azimuth.

The Whitehead Torpedo Mk 3 was developed and produced in the 3.55-meter version only. The significant difference between the Mk 3 and the other 3.55-meter torpedoes was that it used the Obry steering gear (gyro) for azimuth control.

Initially, Whitehead torpedoes had used a reciprocating engine in which the exhaust was expelled through a hole in the afterbody. This method of exhaust, however, interfered with the torpedo steering. Peter Brotherhood, an employee of the Royal Laboratories, Woolrich, England, developed a reciprocating engine which exhausted into the crankcase and then the exhaust was ducted out the tail of the torpedo through a hollow drive shaft.

The Brotherhood engine, along with contrarotating drive shafts developed by another Woolrich employee, was adopted by Whitehead about 1880. These innovations improved steering and eliminated the heel-and-roll tendency due to a single propeller. A Mr. Rendel was granted a patent in 1871 for double propeller propulsion, but whether he was the Woolrich employee referred to is not known.

Ultimately, in order to free himself from the Brotherhood patents, Whitehead redesigned the engine by changing the valves from the rotary slide type to vertical poppets. (A U.S. Whitehead Torpedo is shown in figure 12.)

Whitehead engines were operated by compressed air and were classified as "cold running" torpedoes. The advantage of hot gases for improving the efficiency was evidently well understood, since unsuccessful attempts were made to heat the air in the air flask by burning a spray of liquid fuel in the air flask itself. These early attempts led to the use of an air heater or "combustion pot" (also referred to as a "superheater") between the air flask and the engine. Torpedoes with an air heater became known as "hot running," and those without, "cold running."

Figure 12. USS MORRIS (USTB 14) Launching Whitehead Torpedo

About 1901, the last model of the Whitehead torpedo to be used by the U.S. Navy was introduced. A hot running torpedo, the Whitehead Mk 5 used an air heater or combustion pot (with kerosene as a fuel) and a four-cylinder reciprocating engine. The result of using heated air was remarkable. The Whitehead Torpedo Mk 5 ran 4000 yards at 27 knots, an increase in range by a factor of 5. In this model, provision was made for varying the speed and range in three steps: 4000 yards at 27 knots; 2000 yards at 36 knots; 1000 yards at 40 knots. This was accomplished by physically changing the reducing valve plug or varying its setting in the reducing valve, controlling the pressure/flow of air and fuel to the combustion pot. The adjustment was made prior to tube loading through an access hole provided in the torpedo hull.

THE SCHWARTZKOPFF TORPEDO PURCHASE

In 1898, 12 Schwartzkopff Torpedoes were purchased by the U.S. Navy, but these torpedoes receive only passing mention in history. One of the European nations that also purchased this type of torpedo was motivated by curiosity, in view of Schwartzkopff claims and by the corrosion resistance offered by the all-bronze construction. In the case of that nation, tests with the Whitehead Torpedo demonstrated overall superiority over the Schwartzkopff version. Although unsaid, the U.S. experience was probably the same since this was the one and only purchase of Schwartzkopff Torpedoes by the U.S.

BLISS-LEAVITT TORPEDOES

In 1904, Frank McDowell Leavitt, an engineer for the E. W. Bliss Co., developed a new torpedo, the Bliss-Leavitt Mk 1. This torpedo was powered by a single-stage, vertical (plane of rotation) turbine which also had a combustion pot, and used alcohol as fuel to heat the air before entering the engine.

The developmental model of the Bliss-Leavitt Mk 1 torpedo used an air flask pressure of 1500 psi and ran cold with a speed of 30 knots for 1200 yards. With an air flask designed for 2200 psi and a "superheater," speeds of 35 knots for 1200 yards, 29-1/2 knots for 2000 yards, and 24-1/2 knots for 3000 yards were obtained. The production version of the Mk 1 with an air flask pressure of 2250 psi and a superheater, ran at 27 knots for 4000 yards.

The Bliss-Leavitt Mk 1 had one significant shortcoming. The single-stage turbine drove a single propeller resulting in an unbalanced torque which caused the torpedo to roll. This was corrected in subsequent Bliss-Leavitt torpedoes by using a two-stage turbine driving contrarotating propellers. Development of the two-stage, balanced turbine is credited to Lt. Gregory Davison, U.S.N. The two-stage turbine was essentially the same power plant used in all U.S. "steam" torpedoes through World War II, except for minor engineering changes and for the change in the plane of rotation from vertical to horizontal.

With the introduction of the Bliss-Leavitt Mk 1 and the Whitehead Mk 5, there were seven torpedoes which the U.S. Navy either had purchased or would purchase for Fleet use. The torpedoes were:

1. Whitehead Mk 1 (3.55 meters x 45 centimeters),
2. Whitehead Mk 1 (5 meters x 45 centimeters),
3. Whitehead Mk 2 (3.55 meters x 45 centimeters),
4. Whitehead Mk 2 (5 meters x 45 centimeters),
5. Whitehead Mk 3 (3.55 meters x 45 centimeters),
6. Bliss-Leavitt Mk 1 (5 meters x 53 centimeters),
7. Whitehead Mk 5 (5.2 meters x 45 centimeters).

Except for the Bliss-Leavitt Mk 1 and the Whitehead Mk 5 torpedoes, both of which had a device for azimuth control, all were "cold running."

Bliss-Leavitt continued development of the "hot-running" torpedo. The Mk 2 and Mk 3 were similar but had slight differences in performance; both did have two-stage, contrarotating turbines which drove contrarotating propellers, thus eliminating the roll tendency found in the Bliss-Leavitt Mk 1.

The Bliss-Leavitt Torpedo Mk 4 was an 18-inch torpedo utilized in the torpedo boats and submarines of the period around 1908.

There is no indication that there ever was a Bliss-Leavitt Mk 5 torpedo. It should be noted, however, that mark numbers were assigned by BuOrd and were not designations that were assigned by the developer/ manufacturer. The absence of a mark number then does not indicate a lapse in an evolutionary process, but merely a halt to the early practice of assigning the same mark number to two devices differentiated only by the developer's name.

EXPLODER MECHANISMS

All of the early torpedoes employed a mechanical impact warhead detonating mechanism. These devices used percussion caps to initiate the detonation of the explosive train, and, where used, the primers (boosters) were dry guncotton placed bare in the primer case (exploder cavity) prior to installation of the mechanism. The detonating mechanisms were called "war noses."

War Nose Mk 1 was designed and manufactured by the Whitehead Torpedo Works, Weymouth, England, prior to 1900. The war nose was mounted in the primer case (exploder cavity) in the forward end of the warhead, on the longitudinal centerline of the torpedo. A firing pin capable of longitudinal motion within the body of the war nose was held in place away from the percussion cap by a shear pin made of tin. Upon impact with the target, the shear pin would be cut and the firing pin would impact the percussion cap initiating detonation of the explosive train.

To prevent accidental detonation during handling, war nose installation, tube loading, etc., the war nose had a mechanical arming feature. A screw fan (propeller) located on the forward end of the war nose (figure 13), had to be rotated about 20 revolutions (equivalent to about 70 yards of torpedo travel through the water) before the firing pin was free to move and impact the percussion cap.

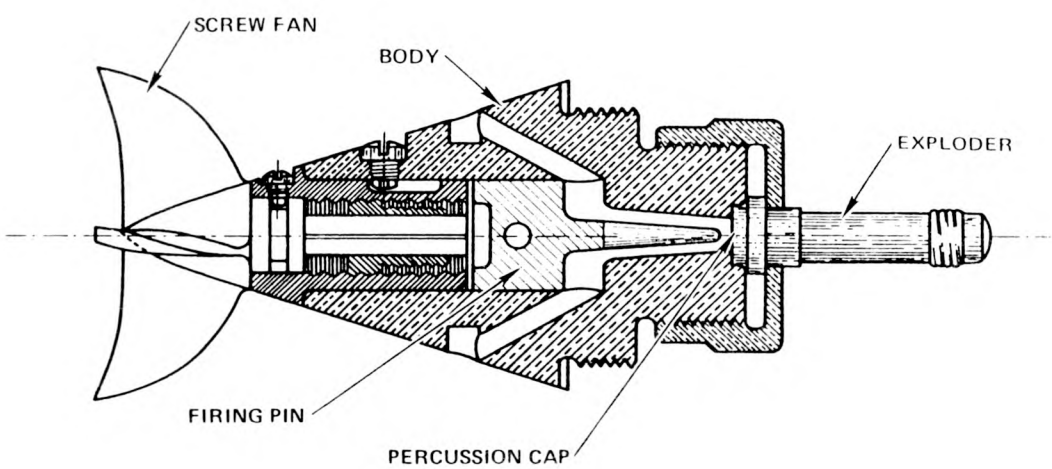


Figure 13. War Nose Mk 1

War Nose Mk 1 weighed about 2-1/2 pounds, was 6 inches long and 2-1/2 inches in diameter. A very simple device, the war nose was sensitive only when impact with the target was directly on the war nose along the torpedo longitudinal axis.

War Nose Mk 2 Mod 0 was slightly larger than the Mk 1. It weighed 4-1/2 pounds, was 6-1/2 inches long and 3 inches in diameter; the same detonator as the Mk 1 was used, but a primer of dry guncotton was also used to insure detonation of the warhead.

The main advantage of the Mk 2 war nose was that it had four levers (whiskers) extending outward from the body casting which would, if struck, cause the firing pin to impact the detonator. This war nose would cause warhead detonation if struck with something less than a direct blow on the end of the war nose. War Nose Mk 2 had the same safety features as did the Mk 1.

War Nose Mk 2 Mod 1 weighed 8 pounds, was 8 inches long, and 4 inches in diameter. Identical to War Nose Mk 2 Mod 0 except for minor mechanical details, the Mod 1 had longer whiskers and thus would fire on a more glancing blow.

War Noses Mk 3 and Mk 4 never materialized beyond the experimental stage. The Mk 3 was a Mk 2 Mod 1 version with longer whiskers. The Mk 4 was an experimental model of the War Nose Mk 5 that followed the Mk 4 version.

War Nose Mk 5 was the first warhead detonating device designed to fire on impact from any angle/direction. It was also the first to have a safety device that kept the screw fan from turning while in a submerged tube. In addition, the Mk 5 incorporated a multiple detonator system to eliminate failures from this aspect. Designed for use with slow speed torpedoes, War Nose Mk 5 was unsatisfactory when torpedo speeds approached 30 knots because the releasing pin plate, which prevented the screw fan from turning prior to torpedo launch, bound due to frictional forces. The Mk 5, which was about 11 inches long, 2 inches in diameter, and weighed about 5 pounds, employed a complicated firing mechanism that downgraded its reliability.

The war noses already noted were designed and reportedly used in torpedoes up until 1911. There is no indication that detonating devices subsequent to the war noses were interchangeable with their earlier counterparts; consequently, it may be reasonably assumed that war noses continued in use until the torpedoes that utilized them were condemned around 1922.

During the period 1911-1915, the USNTS, Newport, R.I., developed Exploder Mechanism Mk 1. (This was a change in nomenclature. With the war noses, "exploders" was the nomenclature associated with what are now called detonators.) Exploder Mk 1 had several mechanical defects and was replaced by Exploder Mk 2; however, improvements to the Mk 2 brought about the Mk 3 before manufacture of the Mk 2 was completed. Consequently, the first U.S. Navy exploder mechanism was the Mk 3 "simple exploder."

It is interesting to note that the anticircular run (ACR) feature, now incorporated in most torpedo course gyros, was initially a part of the exploder mechanism. This device sterilized the exploder (prevented detonation) if the torpedo turned 110° from the original course. Like modern ACR devices, it was operable only during the initial part of the run.

With much emphasis on devices that cause detonation of the warhead if the torpedo passes under the target, approximately 20 different types of exploders have been developed with varying degrees of success.

EXPLOSIVES

Guncotton (nitro-cellulose) was the universally used explosive for torpedo warheads up to about 1912. At that time it was planned to use TNT (Trinitrotoluol) for all future warheads. Indications are that the use of TNT started around 1911 and was continued until the introduction of Torpex in 1930. Torpex was replaced by HBX in the 1940's, followed by H-6 in the 1960's. Torpex, HBX, and H-6 were all basically TNT with additives to increase the explosive yield, or improve the stability/ reduce long-term storage deterioration. PBX, the explosive currently in use, evolved in the early 1970's.

Consistent with its established purpose, much of the production effort in the early days of the Torpedo Station at Newport was concentrated on manufacturing main charge explosives and explosive components (primers and detonators).

The effort being applied to torpedoes, per se, was in component development, ranging/acceptance of torpedoes manufactured by E. W. Bliss Co., coupled with experiments in launching torpedoes from the various platforms. From the first, torpedo acceptance by the U.S. Navy was on the basis of in-water performance. To facilitate torpedo launching experiments, the Navy's prototype torpedo boat "USS STILLETTO" and the first of the new torpedo boat class "USS CUSHING" (USTB 1) along with early submarines "USS HOLLAND," "USS ADDER," and "USS MOCASSIN" were among the ships assigned to the USNTS, Newport, for this purpose.

Emphasis in the efforts of the USNTS was soon to change. Early in 1907, explosive main charge manufacturing and all equipment for that purpose were transferred to Indian Head, Md.

THE U.S. NAVY TORPEDO FACTORY

About 1906, Admiral N. E. Mason, then Chief of BuOrd, requested an appropriation of $500,000 from Congress of which $150,000 was for the purpose of establishing a U.S. Navy Torpedo Factory at Newport, R.I. He was apparently successful, for construction of the factory began on July 1, 1907, and in 1908, the Naval Torpedo Station in Newport (the torpedo factory) received an order for 20 Whitehead Mk 5 torpedoes.

In the light of establishing a competitor to E. W. Bliss Co., who had enjoyed a virtual monopoly in supplying torpedoes to the U.S. Navy, the climate was probably more favorable for dealing with Whitehead rather than Bliss for manufacturing rights, tooling, etc. At the same time, an order for additional Whitehead Mk 5 torpedoes was placed with Vickers Ltd., in England, perhaps an indication of a strained relationship between the U.S. Navy and the Bliss Co.

Bliss staged a comeback with the Bliss-Leavitt Mk 6 torpedo in 1911 which used horizontal turbines (spin axis at right angles to the longitudinal centerline). An 18-inch diameter torpedo intended for above-water launching, this weapon could obtain a speed of 35 knots but a range of only 2000 yards.

THE "STEAM" TORPEDO

The Bliss-Leavitt Mk 7 torpedo was the next significant step forward in technology. A water spray was introduced into the combustion pot along with the fuel spray and the "steam" torpedo came into being.

Torpedo Mk 7, with a range of 6000 yards at 35 knots, was introduced into the Fleet about 1912 and was in use for 33 years up to and including World War II when it was used in reactivated World War I destroyers (with 18-inch torpedo tubes).

In the "steam" torpedo, air, fuel, and water are simultaneously fed into the combustion pot. The fuel burns and the water reduces the temperature of the gases produced by combustion. The water turns into steam, thus increasing the mass of the gas. The gases generated by combustion and the steam provide the motive power to the engine. Although only a fraction of the gases is steam, the term "steam" torpedo has been generally used throughout the years (figure 14).

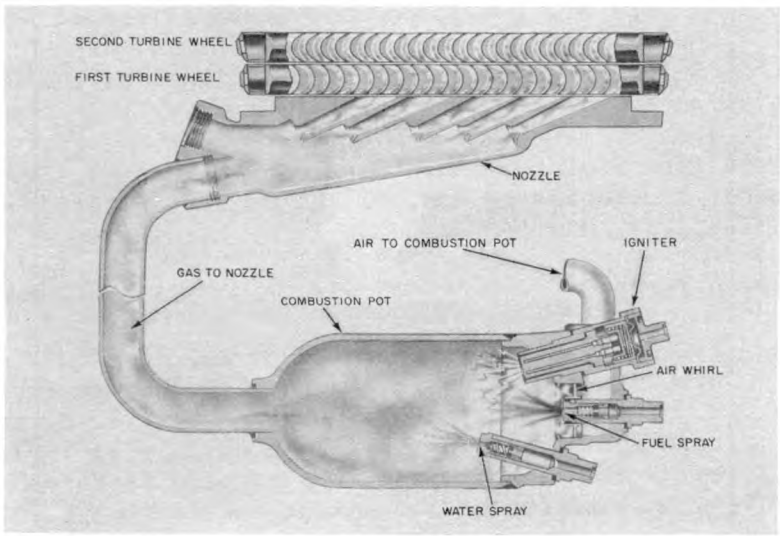


Figure 14. Typical Hot Gas Generator System of Steam Torpedo

TORPEDO DESIGNATIONS OF 1913

By 1913, the U.S. Navy inventory of torpedoes included both "hot" and "cold" running Whitehead and Bliss-Leavitt design torpedoes, with some identified by the same Mark. Consequently, new designations were formulated as shown in tables 1 and 2.

Table 1. Cold Serviceable Torpedoes

New Designation	Former Designation	Make	Size
Type A	Mk 3	Whitehead	140 inches x 17.7 inches
Type B	Mk 1 (5-meter)	Whitehead	187 inches x 17.7 inches
Type C	Mk 2 (5-meter)	Whitehead	197 inches x 17.7 inches

Table 2. Hot Serviceable Torpedoes

New Designation	Former Designation	Make	Size
Mk 1 Mod 1	Mk 1	Bliss-Leavitt	197 inches x 21 inches
Mk 2	Mk 2	Bliss-Leavitt	197 inches x 21 inches
Mk 3	Mk 3	Bliss-Leavitt	197 inches x 21 inches
Mk 4	Mk 4	Bliss-Leavitt	197 inches x 17.7 inches
Mk 5	Mk 5	Whitehead	197 inches x 17.7 inches
Mk 6	Mk 6	Bliss-Leavitt	204 inches x 17.7 inches
Mk 7	Mk 7	Bliss-Leavitt	204 inches x 17.7 inches
Mk 8	Mk 8	Bliss-Leavitt	256.3 inches x 21 inches

All other torpedoes in the inventory (i.e., Howell, Whitehead Mk 1, and Whitehead Mk 2 (3.55-meter versions) and the Whitehead and Schwartzkopff torpedoes of foreign manufacture that were purchased or captured during the Spanish-American War) were condemned against further service use.

THE TORPEDO BOAT

The use of the torpedo as an offensive weapon gave rise to the need for developing a delivery platform, the torpedo boat. The U.S. Navy's prototype of the torpedo boat, the "USS STILLETTO," was built as an unarmed steam yacht by Herreshoff in Bristol, R.I., and introduced into the Navy in 1887. It was assigned to the Torpedo Station in Newport for torpedo experiments and designated Wooden Torpedo Boat (WTB 1).

In 1890, the USS CUSHING (TB 1), the first of the U.S. Navy's new class of torpedo boats, was commissioned and assigned to Newport. Torpedo boats of the CUSHING class were 140 feet long, displaced 116 tons, had a top speed of 23 knots, and were equipped with two or three 18-inch torpedo tubes. In 1893, the fixed torpedo tubes in USS CUSHING were replaced with trainable torpedo tubes (a design attributed to Lt. F. F. Fletcher, U.S.N.) which increased her tactical flexibility. Each year larger and faster torpedo boats were developed. In 1895, Japanese torpedo boats attacked the Chinese fleet at anchor with a loss to the Chinese of 14,000 tons. This action appears to have been a major factor in development of the torpedo boat countermeasure - the torpedo boat destroyer.

THE TORPEDO BOAT DESTROYER

The USS BAINBRIDGE (DD 1), launched in 1901, was the first U.S. Navy torpedo boat destroyer. (In a few years, ships of this type became known simply as destroyers.) The BAINBRIDGE displaced 420 tons, had a maximum speed of 29 knots, and was armed with 3-inch guns and two 18-inch torpedo tubes. These destroyers of torpedo boats were, in fact, torpedo boats as well. Shortly before the first World War in 1913, the DUNCAN class, 1020 tons, came into being; they were equipped with 18-inch, double- or triple-mount torpedo tubes firing the Bliss-Leavitt Mk 6 and Mk 7 torpedoes. Beginning with the USS CALDWELL (DD 69) in 1917, the raised forecastle gave way to flush decks, displacement increased to 1200 tons, and speed increased to 32 to 35 knots. Of far reaching significance, the advent of the DD 69 also introduced the standard 21-inch surface torpedo tube. With tubes installed in triple mounts, four mounts per ship (12 tubes in all), these ships fired the Bliss-Leavitt Mk 8, the U.S. Navy's first 21-inch by 21-foot torpedo, with a range of 16,000 yards at a speed of 27 knots.

THE SUBMARINE

In 1900, the U.S. Navy's first submarine, USS HOLLAND (SS-1), came to Newport for demonstration and test. In 1901, while carrying three Whitehead Mk 2 torpedoes, the HOLLAND was exercised with a Navy crew from the Torpedo Station. Lt. Harry H. Caldwell, who is believed to be the U.S. Navy's first

submarine officer, was in command. In exercises off the coast of Newport, the HOLLAND closed to within torpedo firing range of the USS KEARSARGE (BB 5) without being detected.

The HOLLAND was followed by other U.S. Navy submarines in tests and experiments at Newport. These early "A" type submarines such as the USS ADDER and USS MOCASSIN were equipped with one bow-mounted, 18-inch torpedo tube. During the submarine's days of infancy, later classes had two or four 18-inch torpedo tubes installed and carried a total complement of four to eight torpedoes on board. The exception was the G-3 which had six 18-inch torpedo tubes installed and carried a total complement of ten torpedoes. The ultimate torpedo for these early submarines was the Bliss-Leavitt Mk 7.

Like the surface Navy, submarines were standardized with 21-inch torpedo tubes beginning in 1918 with the "R" class. Submarines equipped with the 21-inch torpedo tubes used Torpedo Mk 10, which had the heaviest warhead of any torpedo up to that time, 500 pounds, with a speed of 36 knots, but a range of only 3500 yards. This torpedo was a development of the USNTS, Newport, with the assistance of the E. W. Bliss Co.

Bliss-Leavitt Torpedo Mk 9 was developed about the same time as Torpedo Mk 10 (1915). It was intended to replace Bliss-Leavitt Mk 3-type torpedoes in battleships. When use of torpedoes in battleships was discontinued in 1922, the Mk 9 was converted for submarine use and was used in the early days of World War II to supplement the limited stock of Mk 14's.

The last of the Bliss-Leavitt torpedoes, the Mk 9 appears to have been a misfit in the evolutionary process. It was slow, had a short range for a surface ship torpedo, carried a small explosive charge and air flask pressure was reduced to 2000 psi from 2500-2800 psi. There was apparently some effort to improve Mk 9 capability, for in follow-on mods, its speed was unchanged and range in some cases reduced, while the explosive charge was increased to around 400 pounds and air flask pressure was increased to 2800 psi (indicating use of a new air flask).

WORLD WAR I AND THE AFTERMATH (1915-1929)

WORLD WAR I

During this time period, the U.S. entered World War I. By the spring of 1917, the German U-boat menace had become so great that it overshadowed all other enemy threats. Torpedo research and development was practically discontinued in favor of the development of depth bombs, aero bombs, and mines, which were the antisubmarine warfare weapons of that era. The resources of the Naval Torpedo Station at Newport were redirected to this end and played an important role in wartime development, particularly in the development of the U.S. depth bomb which supplanted the British design.

The use of the torpedo by the U.S. Navy and the Allies in World War I was a negligible factor (specific data are not available); on the other hand, German submarines are credited with sinking 5,408 ships for a total of 11,189,000 tons.

U.S. NAVY ELECTRIC TORPEDO DEVELOPMENT

Development of an electric torpedo started around July 1915, with the Sperry Gyroscope Company of Brooklyn, N. Y. The characteristics were as follows:

Range - 3800 yards,
Speed - 25 knots,
Diameter - 7-1/4 inches,
Length - 72 inches (without explosive charge),
Weight - 90 pounds (without explosive charge).

The propulsion motor of the proposed electric torpedo was to act as a gyroscope to stabilize the torpedo in azimuth, as in the old Howell Torpedo. This development was terminated in 1918 with no torpedoes having been produced.

Navy interest in the development of an electric torpedo, prompted by the successful development of one during World War I in Germany, continued after termination of the Sperry contract. Navy in-house development of an electric torpedo of conventional size continued at the Navy Experiment Station, New London, Conn. This design was designated the Type EL, then the Mk 1.

In 1919, the Navy Experiment Station was closed as an economy measure, and the development of the Mk 1 was assigned to the USNTS, Newport. Development continued sporadically over the next 25 years on the Mk 1 and Mk 2 electric torpedoes culminating finally with the Mk 20.

AFTER THE WAR WAS OVER

World-wide reduction in naval armament during the 1920's resulted in a wave of reduced expenditures for military purposes. Appropriations for torpedo research and development were small, with an allocation of approximately $30,000 per year for the Torpedo Station at Newport during this era.

In the same wave of economy, development and manufacture of torpedoes for the U.S. Navy at the E. W. Bliss Co. was terminated in the early 1920's, upon completion of the Torpedo Mk 9 project. Disputes over patent rights, and also the fact that the USNTS, Newport, with 15 years of experience in torpedo manufacture was considered capable of providing for the Navy's needs, were cited as factors influencing termination of work with the Bliss Co. Economy seems to have been the primary motivation, for at the same time, torpedo manufacturing activities at the Washington Navy Yard and the Naval Torpedo Station in Alexandria, Va., were halted. The Newport Torpedo Station became the headquarters for torpedo research, development, design, manufacture, overhaul, and ranging.

In 1922, in a move to reduce maintenance costs, all torpedoes of design prior to the Bliss-Leavitt Torpedo Mk 7 were condemned (withdrawn from service and probably scrapped) in favor of more modern torpedoes. With this move, the U.S. Navy inventory of torpedo types then consisted of four models:

1. Torpedo Mk 7 - used by destroyers and submarines with 18-inch tubes,

2. Torpedo Mk 8 - used by destroyers with 21-inch tubes,

3. Torpedo Mk 9 - converted for use with 21-inch submarine tubes, and

4. Torpedo Mk 10 - used by submarines with 21-inch tubes.

In the mid-1920's, manufacturing efforts were minimal, and the efforts were mainly concerned with improving the existing torpedo inventory. Development of Torpedo Mk 11, which was started at the Washington Navy Yard, was completed by the Torpedo Station at Newport in 1926. This torpedo, which was intended for use by destroyers and cruisers, had multirange/speed selection: 6000 yards at 46 knots, 10,000 yards at 34 knots, or 15,000 yards at 27 knots. (Cruiser use of torpedoes was discontinued in 1936.) Production of Torpedo Mk 11 started in 1927; however, in 1928, the Mk 11 was succeeded by the Mk 12, which was similar but refined in many details. About 200 Mk 12's were produced.

The 1930's were the development/production years for Torpedoes Mk 13 (aircraft), Mk 14 (submarine), and Mk 15 (destroyer), which constituted the U.S. "modern" torpedo inventory at the start of World War II.

PRE-WORLD WAR II ERA (1930-1939)

DEVELOPMENT OF THE AIRCRAFT TORPEDO MK 13

The development of the aircraft torpedo covered a time span of about 25 years. It involved two Navy Bureaus - Ordnance and Aeronautics (the latter due to the necessity of parallel development of a satisfactory torpedo plane).

The first experimental air drops were made in May 1920 at the Naval Air Station, Anacostia, Md., using two Torpedoes Mk 7 Mod 5. Air speed for these drops is believed to have been 50 to 55 knots at altitudes of 18 and 30 feet. It was found that the torpedo dropped from 30 feet was badly damaged while the one dropped from 18 feet was not.

The prime mover in the early days of Naval aviation, particularly with respect to the use of the torpedo as an aircraft strike weapon, was Rear Adm. Bradley A. Fiske, U.S.N. He was granted a patent for the torpedo plane in 1912. Included in his patent were proposed methods for the tactical use of the aircraft torpedo, which were used by the U.S. Navy for many years.

A degree of the interest in the aircraft torpedo is evidenced by the fact that an Aviation Unit for the Newport Torpedo Station was established at Gould Island, R.I., in 1921. It was at this facility that the bulk of the testing that ultimately resulted in the aircraft torpedo was accomplished.

In the beginning, efforts were directed towards modification/adaptation of existing torpedoes for aircraft application. By 1924, Torpedoes Mk 7 were being launched successfully from DT 2 torpedo planes at air speed of 95 knots from an altitude of 32 feet. An air-dropped Mk 7 is shown in figure 15.

In February 1925, BuOrd initiated "Project G-6" to develop a torpedo specifically for aircraft launching with the following specifications:

Weight (warshot) - 2000 pounds,
Warhead charge - 350 pounds,
Minimum range - 4000 yards,
Minimum speed - 35 knots,
Diameter - 21 inches,
Length - not to exceed 18 feet.

The torpedo was also to withstand launching speed of 140 mph from an altitude of at least 40 feet.

In 1926, Project G-6 was discontinued in favor of adapting existing 18-inch torpedoes. The moratorium was short-lived and Project G-6 was revived in 1927 upon the urging of the Chief of the Bureau of Aeronautics. The intent was to develop a torpedo designed to meet aircraft requirements, in order that production could be started before the existing stock of 18-inch torpedoes was depleted.

After a period of vacillation, specifications were revised in 1929. The torpedo was to be capable of launch at 100 knots (ground speed) from an altitude of 50 feet. Other specifications included:

Range - 7000 yards,
Speed - 30 knots/minimum,
Weight (warshot) - 1700 pounds,
Warhead charge - 400 pounds,
Diameter - 23 inches,
Length - 13 feet 6 inches (maximum).

The design that evolved from these specifications was the 13-foot, 6-inch by 22.5-inch torpedo which was designated the Mk 13 in August 1930. Work on Project G-6 was again halted from October 1930 to July 1931 due to the elimination of the torpedo squadron from the Carrier Air Group planned for the USS RANGER (CV 4).

In March 1933, the question of whether or not there would be a torpedo plane was aired. The question not only arose out of the undesirable features of the plane (T4M/TG) then in use (poor performance, poor capability

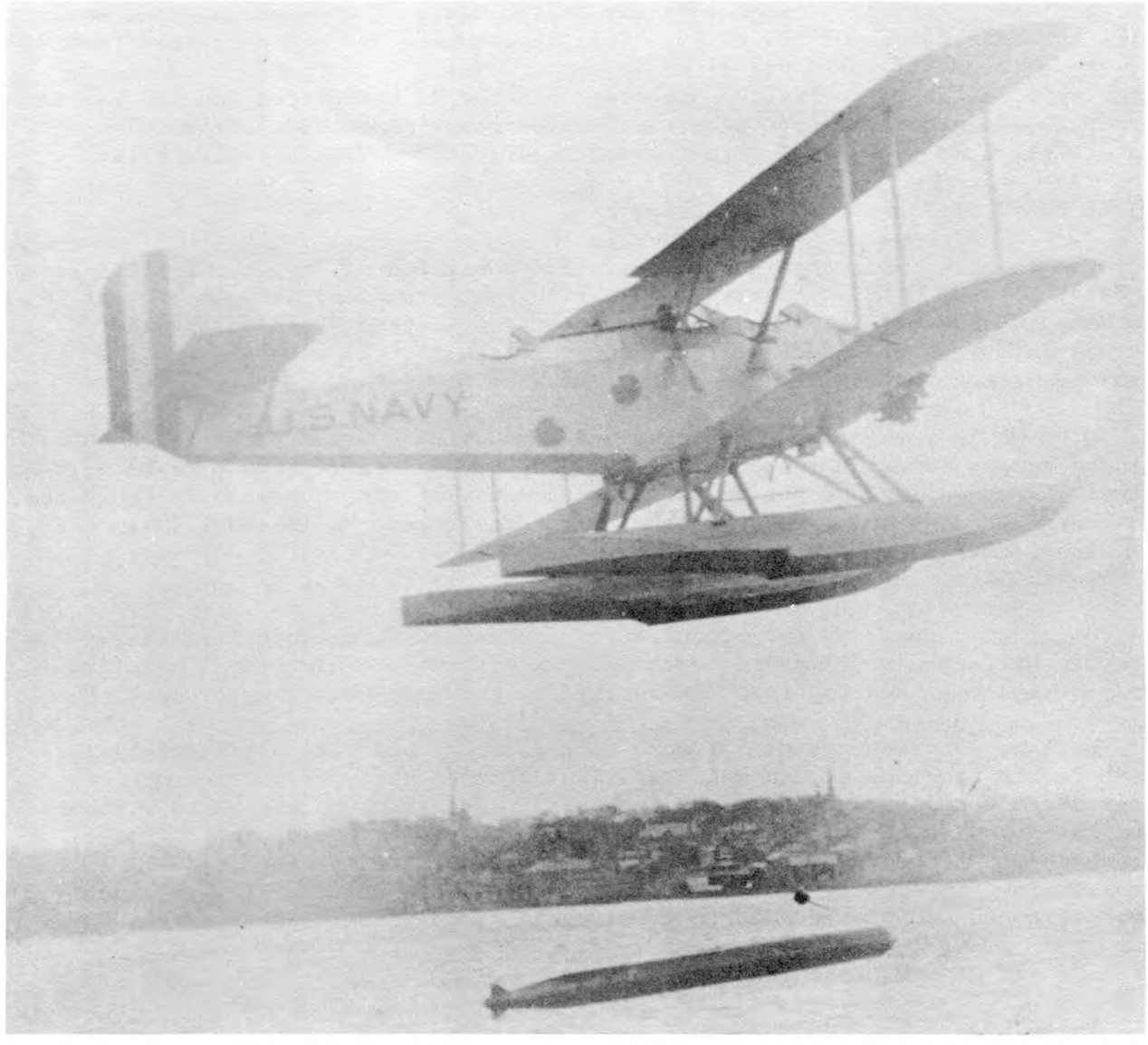


Figure 15. Aircraft-Dropped Torpedo Mk 7

for self-defense, large size, and high cost of operation and maintenance) but also because of poor torpedo performance. These two factors tended to result in tactical ineffectiveness and large losses of material.

The Bureau of Aeronautics, in essence, withdrew support for the Mk 13 type torpedo, favoring instead the development of a 1000-pound torpedo for use from bombing aircraft with these specifications: (1) capable of launching at 125 knots from an altitude of 50 feet; (2) range, 2000 yards; and (3) speed, 30 knots.

At the time, BuOrd considered that the development of the 1000-pound torpedo was practically impossible within the state of the art and continued with the development of the Mk 13. This development was given greater impetus by the outbreak of World War II in September of 1939. Torpedo Mk 13 was available, although in limited numbers, when the United States entered the war in 1941. Aircraft employed were the Douglas Devastator (TBD, circa 1937) and, later, the Grumman/General Motors Avenger (TBF and/or TBM, both circa 1941).

DEVELOPMENT OF THE SUBMARINE TORPEDO MK 14

The submarine torpedo inventory of 1930 consisted of Torpedo Mk 7 (18-inch tubes), Torpedo Mk 9 (converted from battleship torpedoes), and Torpedo Mk 10 (developed about 1915). The development of the Torpedo Mk 14 during the decade following provided a 21-inch modern steam torpedo with a two-speed/range capability and a large warhead.

With Mk 14 development completed and production started prior to the start of the second World War, approximately 13,000 torpedoes of this type were manufactured during the war years. The mainstay of the submarine force in the war until the advent of the wakeless, electric Torpedo Mk 18 about 1944, the Mk 14 is credited with sinking approximately 4,000,000 tons of Japanese shipping.

Originally designed and produced for mechanical fire control setting, Torpedo Mk 14 was modified to be compatible with modern electrical-set fire control systems, and continues in service in today's submarine forces.

Wartime service demands for more torpedoes and scarcity of materials in 1943 led to development and manufacture of Torpedo Mk 23, a short-range, high-speed torpedo (4500 yards at 46 knots). Identical to the Mk 14 without the low-speed feature, this torpedo was not favored by the operating forces since the multispeed option of the Mk 14 permitted greater tactical flexibility, especially during the latter stages of World War II, when more sophisticated escorts and ASW tactics forced firing from longer ranges.

DEVELOPMENT OF THE DESTROYER TORPEDO MK 15

In the years between the World Wars, destroyer construction ceased with the commissioning of the last of 273 flush-decked, four stackers in 1922. No new destroyers were commissioned in the years between 1922 and 1934.

The USS FARRAGUT (DD 348), commissioned in 1934, embodied many innovations such as welded hull construction, a high-pressure, steam power plant, improved gun and torpedo fire control systems; and a 5-inch/38-caliber dual-purpose gun to replace the old 4-inch one. The modern destroyer of this and later classes was equipped with multiple-mount, 21-inch torpedo tubes.

The limited inventory of destroyer Torpedoes Mk 11 and Mk 12 developed and produced during the economy years (1920's), coupled with limited warhead size (500 pounds), were factors leading to the development of Torpedo Mk 15 in 1931. With speed and range similar to its predecessors, it was longer and

heavier due to the increase in the size of the warhead from 500 to 825 pounds. Development of the Mk 15 was completed prior to the start of World War II. Production started and continued during the war years to the extent that approximately 9700 Torpedoes Mk 15 were manufactured.

Decisively used on occasion during the war in the Pacific, the Mk 15 died a natural death when the 21-inch torpedo tubes were removed from destroyers during the Fleet rehabilitation and modernization program of the 1950's, to make way for ASW weaponry consistent with the emerging role of the destroyer as an ASW platform.

WORLD WAR II ERA (1939-1950)

NATIONAL DEFENSE RESEARCH COMMITTEE

In June 1940, President Roosevelt appointed a group of eminent civilian scientists to be members of the National Defense Research Committee (NDRC). Dr. James B. Conat, President of Harvard University, was appointed chairman. Others named were Dr. Karl Compton, President of the Massachusetts Institute of Technology (M.I.T.) and Dr. Frank B. Jewett, President of the National Academy of Science. It was established as a unit of the Office of Scientific Research and Development (OSRD), which was headed by Dr. Vannevar Bush, President of the Carnegie Institution in Washington, D.C. The main objectives of NDRC were to: (1) recommend to OSRD suitable projects and research programs on the instrumentalities of war, and (2) initiate research projects on request of the U.S. Army and Navy or allied counterparts. NDRC, as finally constituted, consisted of 23 divisions, each specializing in a particular field.

Division 6 (Sub-Surface Warfare, headed by Dr. John T. Tate) was the group tasked with the torpedo research and development role. The division's first objective was "the most complete investigation possible of all the factors and phenomena involved in the accurate detection of submerged or partially submerged submarines and in anti-submarine devices."[5] Through the systematic study of all phases of underwater acoustics, the ground work was laid to permit engineering development and deployment of the acoustic homing torpedo during World War II.

THE ELECTRIC TORPEDO MK 18

Capture of the German submarine U 570 in 1941, gave the United States a German G7e electric torpedo (in January 1942), which led to the development of Torpedo Mk 18 by Westinghouse Electric Company at its Sharon, Pa., facility. Within 15 weeks, the first prototype was delivered. Six months from the date of contract award, the first six production units were delivered. Torpedo Mk 18 is credited with having sunk 1,000,000 tons of Japanese shipping during World War II. In addition to being wakeless, electric torpedoes such as the Mk 18 required only about 70 percent of the labor required to manufacture a torpedo with thermal propulsion.

The electric torpedo differed from its predecessors in that the air flask was replaced by a battery compartment which housed the energy source (batteries). The engine and its accessories were replaced by an electric motor, and with electrical power available, electric controls were generally used. In the Mk 18, the climate of war urgency dictated the use of tried and proven pneumatic controls, with the high-pressure air stored in air bottles in the afterbody.

The electric torpedoes used in World War II utilized lead-acid secondary batteries as a power source. These batteries required periodic maintenance, (i.e., checking specific gravity of electrolyte, addition of electrolyte and periodic charging).

One of the main problems with use of the submarine torpedoes was that battery maintenance had to be performed in the torpedo room while on patrol. On the other hand, the aircraft torpedo was returned to a base, carrier, or tender if not launched, and could be broken down to perform the necessary battery maintenance. To facilitate maintenance, the battery compartments of submarine torpedoes were provided with handholes which permitted access to the batteries and provided a means of purging the compartment of hydrogen which was formed during the changing process or simply by the self discharge of the cells while standing idle.

PASSIVE ACOUSTIC HOMING TORPEDO DEVELOPMENT

In 1943, it became known in the technical community that the Germans were using a torpedo called the German Naval Acoustic Torpedo (GNAT) with terminal homing, a torpedo that guided itself to contact with the target by the noise generated by the ship's propellers (cavitation). German development of the GNAT had been known in the U.S. Intelligence community, and in 1940, the NDRC sponsored a project to develop an acoustic homing torpedo. The project was headed by Western Electric; the homing system effort was centered at the Bell Telephone Laboratories and the Harvard Underwater Sound Laboratory. Engineering development of the torpedo, Mine Mk 24 (mine being a misnomer for security reasons), was assigned to Western Electric Co., Kearney, N.J. and the General Electric (G.E.) Engineering and Consulting Laboratories, Schenectady, N.Y. Following successful evaluation of the prototypes, production was started in 1942 Western Electric Co., Kearney, N.J. and at the G.E. Co., Erie Works, and later at the G.E. Co., Philadelphia, Pa. Approximately 10,000 units were ordered, but the order was reduced due to the high effectiveness of the weapon. (The Mine Mk 24 was also known by the code name "Fido".)

The Mine Mk 30, again a misnomer, was developed by the Brush Development Co., Cleveland, Ohio, concurrent with the Mine Mk 24 because of apprehension regarding the acoustic steering of the Mine Mk 24.

The Mine Mk 30 was unique in that it was only 10 inches in diameter and weighed only 265 pounds including a 50-pound warhead. It was nearly identical to Torpedo Mk 43 Mod 1 which was to follow a decade later except that the Mine Mk 30 employed passive acoustic bearing system rather than the active acoustic homing system of the Torpedo Mk 43 Mod 1.

Development was successfully completed in 1943, but was not produced since Mine Mk 24 had demonstrated satisfactory performance late in 1942.

After making its debut in July 1943 with the sinking of the U 160 in the Atlantic, about 340 Mines Mk 24 (figure 16) were launched by the Allied forces in World War II. Two hundred-four of these were against submarine targets with the following results:

1. Number of attacks on U-boats - 204,

2. Number of U-boats sunk - 37 (18 percent),

3. Number of U-boats damaged - 18 (9 percent).

The U.S. forces, with a better opportunity for adequate training in the use of the mine, achieved the following results from 142 attacks on U-boats:

1. Number of U-boats sunk - 31 (22 percent),

2. Number of U-boats damaged - 15 (10 percent).

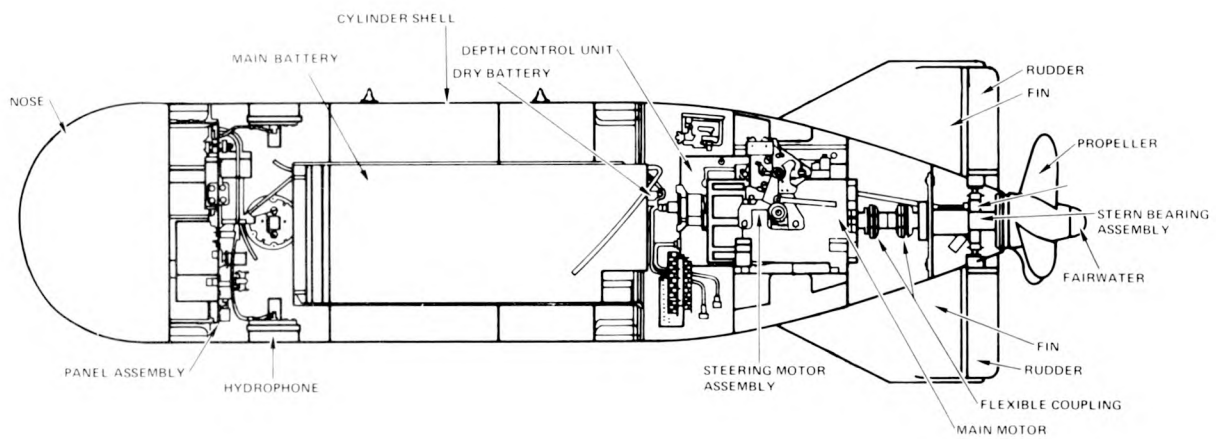


Figure 16. Mine Mk 24

A comparison of the effectiveness of Mine Mk 24 with aircraft-launched depth charges indicate that when depth charges were used, 9.5 percent of the U-boats attacked were sunk, but when Mine Mk 24 was used, 22 percent were sunk.

In approximately the same time frame, engineering development was started at Western Electric on an electric anti-escort torpedo. Torpedo Mk 27 Mod 0, or "Cutie," was the adaptation of Mine Mk 24 for submarine use, and saw service starting late 1944/early 1945 in the Pacific theater.

About 106 Torpedoes Mk 27 Mod 0 were fired during World War II, with 33 hits (31 percent) resulting in 24 ships sunk and 9 ships damaged. Based on an analysis of salvo firing of nonhoming torpedoes against escort-type ships, a single Torpedo Mk 27 achieved the same results against escorts as a salvo of the larger nonhoming torpedoes.

In the departure from the practice of the time for the purpose of obtaining a quiet launching, Torpedo Mk 27 was started while still in the torpedo tube and swam out under its own power, requiring 8 to 10 seconds to clear the tube. The noisy ejection of the conventional torpedo was thus eliminated.

With successful application of the passive homing feature to "mission kill" or crippling weapons characterized by small warheads, application to large antisurface ship weapons logically followed, thus, the development of Torpedo Mk 28 by Westinghouse Electric Corp., Sharon, Pa., in the later World War II years. The Mk 28 was a full-size (21-inch diameter by 21-foot length), electrically-propelled submarine torpedo, with a speed of 20 knots and a range of approximately 4000 yards. This torpedo was also gyro-controlled on a preset course for the first 1000 yards, at which point the acoustic homing system was activated. The explosive charge was also increased to approximately 600 pounds.

About 14 Torpedoes Mk 28 were fired during World War II resulting in four hits. Since this torpedo was made available late in the war without adequate training in its tactical use, the number of hits was not as large as expected. The tendency to regard the acoustic homing torpedo as a device that could correct for any kind of fire control error was a factor in its low success rate. Nevertheless, the Mk 28 demonstrated that it was possible to successfully include acoustic homing in a full-size, submarine-launched torpedo.

ACTIVE ACOUSTIC HOMING TORPEDO DEVELOPMENT

The acoustic weapons developed and deployed during World War II were passive; they listened for a sound and then indiscriminately attacked the source. This technique, while far more effective than any preceding it, had limitations against a ship at slow speed, a submarine running deep, a submarine sitting on the bottom, or a ship employing countermeasures such as a stream of bubbles or a noisemaker.

Investigation of the use of echo-ranging equipment or an "active" homing torpedo system was initiated under the auspices of NDRC in 1941 at the G.E. Co. Research Laboratory, Schenectady, N.Y. Active homing differs from passive homing in that, with active homing, the torpedo steers on the basis of the signal returned by the target through reflection of the torpedo's own transmitted signal. In mid-1942, G.E. began development of the first active homing torpedo, Torpedo Mk 32, which was physically similar to Mine Mk 24 (figure 17).

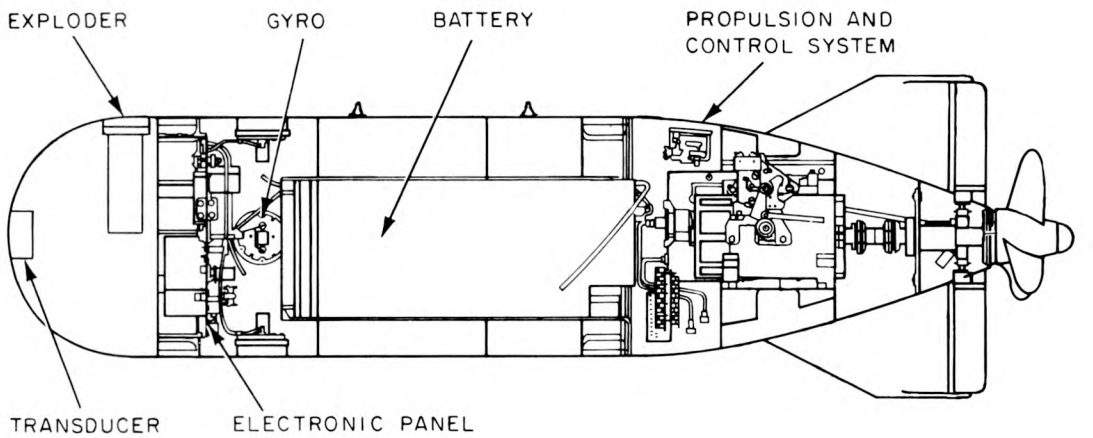


Figure 17. Torpedo Mk 32

By mid-1944, the program had progressed through the successful prototype stage, and due to the saturation of G.E. production facilities with other contracts, Leeds and Northrup of Philadelphia, Pa., was selected as supplier. About ten units were completed when World War II ended, and the project was deactivated until 1951 when Torpedo Mk 32 Mod 2 was produced in quantity by the Philco Corp. of Philadelphia, Pa. Originally intended as an aircraft-launched torpedo, the Mk 32 Mod 2 finally saw service use as a destroyer-launched ASW torpedo until replaced by Torpedo Mk 43.

DEVELOPMENT OF CHEMICAL TORPEDOES MK 16 AND MK 17

Although the chemical torpedo came into being during World War II, basic research which ultimately led to the "chemical" torpedo started about 1915 at Westinghouse Electric and Manufacturing Co. (WECO), Sharon, Pa., under the direction of A. T. Kasley. Early experiments resulted in issuance of two patents to Mr. Kasley, assigned to BuOrd, covering the employment of liquid, solid, and gaseous fuels for the purpose of sustaining exothermic (heat-producing) reactions for the propulsion of torpedoes. The cost of the early experiments was borne by WECO, but later (about 1920) it was put on a contractural basis and continued until late 1926.

At that time, the project was transferred to Naval Research Laboratory (NRL), Washington, D.C. In August 1927, NRL recommended that the WECO approach be abandoned and proposed that increased output of torpedo power plants be achieved by development of an "oxygen" torpedo (use of oxygen in place of air for combustion).

In 1929, the development of an oxygen torpedo was authorized. By 1931, successful dynamometer tank tests had been completed. The torpedo was then

run on the range at USNTS, Newport, when control and propulsion problems were encountered. If the oxygen torpedo was to become a reality, attention had to be focused on supplying oxygen to ships. This was done with limited success.

After an initial flurry of activity, the Navy Department lost interest in the oxygen torpedo but maintained an interest in the development of some kind of chemical torpedo, since it offered promise of tripling the energy output over the steam torpedo with greater flexibility in range, speed, and warhead size.

From 1929 on, NRL studied various chemical sources of energy for torpedoes. In 1934, "Navol" (concentrated hydrogen peroxide H_2O_2) was selected as the proper medium. In 1937, experimentation started with Torpedo Mk 10 as a vehicle using a Navol power plant. In September 1937, this torpedo was brought to USNTS, Newport, for dynamometer tank tests and ranging. The use of Navol increased the range of the standard Torpedo Mk 10 by 275 percent (from 3500 yards to approximately 9500 yards). This demonstration convinced BuOrd that serious consideration should be given to the use of Navol in torpedoes.

NRL was then tasked to apply the principle to Torpedo Mk 14. After a number of successful dynamometer tank runs, the torpedo was run on the range where it made a run of 16,500 yards at 46 knots (standard Mk 14 performance was 4500 yards at 46 knots). At this time (about 1940), manufacture of six torpedoes of this type was begun at USNTS, Newport.

In July 1940, an NRL representative was transferred to Newport on a full-time basis, and the Torpedo Station was authorized to start development of a destroyer-launched, 50-knot torpedo with a range of 16,000 yards and a 600-pound warhead. The end objective was to manufacture 50 torpedoes to be designated as the Mk 17.

After the attack on Pearl Harbor, pressure to produce Torpedo Mk 13 and Torpedo Mk 14 to satisfy immediate Fleet needs was so great that BuOrd postponed the planned manufacture of the Mk 17 even though committed as armament for new construction destroyers.

The program was dormant until 1943 when it was determined that there was not enough Navol production capability available to satisfy the Navy need if the Navol torpedo was to become a reality. After a long delay, construction was started on a Navol production facility at Dresden, N.Y., in the fall of 1944.

In response to a request from BuOrd, Columbia University, Division of War Research, Special Studies Group, established a laboratory at M.I.T. The main objectives were to increase the efficiency of Navol through studies of its decomposition and combustion, to learn how best to handle it, and optimize the torpedo power plant for its use. The laboratory, established with $250,000 from the Office of Scientific Research and Development (OSRD), was in full operation by August, 1945.

In 1943, BuOrd initiated development of Torpedo Mk 16 at USNTS, Newport. A 46-knot, 7000-yard range submarine torpedo, the Mk 16 was to be the same weight and envelope as Torpedo Mk 14. In 1944, the range specification was changed to 11,000 yards and the new torpedo was designated Torpedo Mk 16 Mod 1 (figure 18).

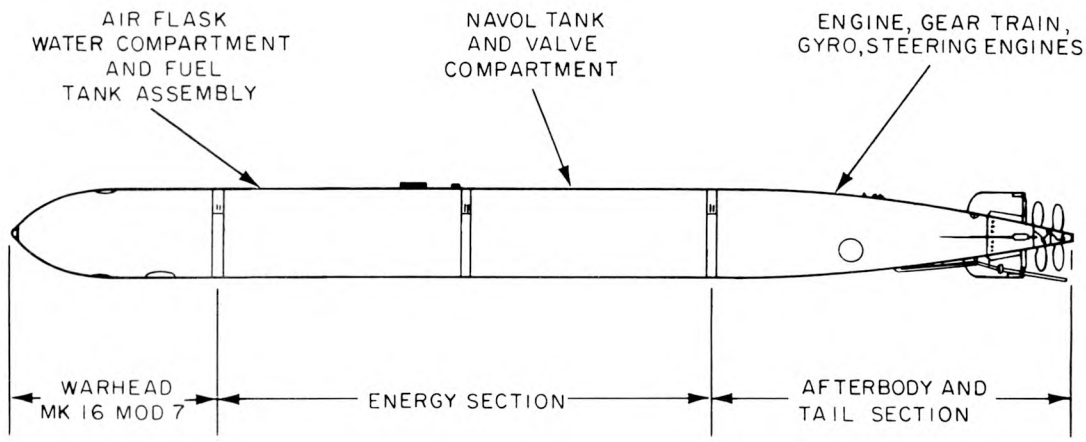


Figure 18. Torpedo Mk 16

In 1944, production of the Mk 17 was resumed. Neither Torpedo Mk 16 nor Mk 17 was fully developed at this time, and it was realized that production units of both torpedoes would probably require extensive changes subsequent to production. This eventuality was acceptable to BuOrd, and a total of 520 Torpedo Mk 16's and 450 Torpedo Mk 17's were produced prior to the end of the war. Neither type, however, was used in combat.

Torpedo Mk 17 saw limited service in post-World War II, but was discontinued about 1950. Its heavy topside weight on destroyers, similarity to Torpedo Mk 16, and the emerging role of destroyers as an antisubmarine warfare (ASW) platform were factors contributing to its early demise.

DEVELOPMENT OF THE TORPEDO MK 25

Lack of experience in launching the aircraft torpedo led to a preference for the aerial bomb, with which most pilots were familiar. This preference was intensified by the low-altitude, slow-speed tactics required for torpedo launch. The problems with such tactics were seen at the Battle of Midway in June 1942. In this battle, torpedo launching runs were made from over the horizon at an altitude of 50 feet and a speed of 110 knots by inadequately protected planes against very strong enemy fighter and anti-aircraft cover, resulting in heavy losses. Thirty-seven out of 41 planes were lost without scoring a single torpedo hit.

By 1943, the attitude of the Fleet towards the Mk 13 torpedo had become so unfavorable that the need to develop a new, more rugged torpedo capable of being launched from higher altitudes and at greater speeds became urgent. In the summer of 1943, NDRC initiated development of Torpedo Mk 25 at Columbia University, Divison of War Research. In addition to having improved launching characteristics, the new torpedo was to be faster (40 knots versus 33 knots), have a shorter range (2500 yards versus 4000 yards), and was to carry more explosive (750 pounds versus 400 pounds).

IMPROVED TORPEDO MK 13

Parallel with the development of the Mk 25, the Mk 13 was undergoing continuous improvement. Most significant was the development of flight-in-air accessories: stabilizers, drag rings, and shroud rings which permitted launching at altitudes of 2400 feet (vice 50 feet) and air speeds of 410 knots (vice 110 knots). With these improvements, the Mk 13 was successfully employed in the latter stages of World War II; the most noteworthy success being its part in the sinking of the 45,000-ton Japanese battleship YAMATO in April 1945 off Kyushu.

In view of the shortcomings of the torpedo which dictated the tactics employed, and in some cases, the early aircraft (TBD), the overall statistical performance of the Torpedo Mk 13 as shown in table 3 is suprising.

Development of Torpedo Mk 25 was completed before the end of the second World War, but the torpedo was never produced for service use. The large inventory of Mk 13's (resulting from wartime production), improvement of Mk 13 performance, and the changing role of Naval aircraft from strike warfare platforms to ASW platforms, undoubtedly influenced this decision.

THE NAVY ELECTRIC TORPEDO MK 20

The development of the Navy electric Torpedo Mk 20 was completed about 1945, after having been through many changes in configuration, including one employing the sea water-activated battery developed by Bell Telephone Laboratories. Due to other successful electric torpedo developments during World War II, the Mk 20 was never produced for service use.

Table 3. Torpedo Attacks and Hits for U.S. Carrier-Based Aircraft (7 Dec 1941 to 31 May 1945)

Class of Targets	Number of Attacks*	Number of Hits	Percentage of Hits
Battleships and carriers	322	162	50
Cruisers	341	114	34
Destroyers	179	55	31
Total warships	842	331	39
Merchant vessels	445	183	41
Total	1287	514	40

*An "attack," for the purpose of this table is defined as one plane attacking one ship with a torpedo.

WORLD WAR II TORPEDO PRODUCTION

As an overview of the level of torpedo activity during World War II, the expanded production capability consisting of the Pontiac Motors Division; the International Harvester Co;, the Naval Torpedo Stations at Newport, Keyport, and Alexandria; and the American Can Co. (Amtorp) at Forest Park, Ill., and St. Louis, Mo., produced nearly 50,000 conventional torpedoes as follows:

Torpedo Mk 13 - 16,600,
Torpedo Mk 14 - 13,000,
Torpedo Mk 15 - 9,700,
Torpedo Mk 23 - 9,600.

Westinghouse Electric Corp., Western Electric Co., and General Electric Co. produced approximately 15,000 of the newer types of torpedoes as follows:

Torpedo Mk 18 - 9,000,
Mine Mk 24 - 4,000,
Torpedo Mk 27 Mod 0 - 1,100,
Torpedo Mk 28 - 1,000.

WORLD WAR II SUBMARINE TORPEDO PERFORMANCE

The overwhelming majority of torpedoes fired during World War II were from submarines in the Pacific theater. Approximately 14,750 torpedoes were fired from submarines at 3184 of the approximately 8200 ships sighted. Of these, 1314 ships were sunk for a total of 5,300,000 tons. In addition, submarines received "probable" credit for another 78 ships of 203,306 tons. The confirmed total included one battleship, eight aircraft carriers, three heavy cruisers and eight light cruisers. These Joint Army Navy Assessment Committee (JANAC) confirmed sinkings (1314) accounted for 55 percent of all Japanese ship losses. The remaining 45 percent were lost to Army and Navy aircraft bombs, mines, and other causes.

EARLY POST-WORLD WAR II

At the end of World War II, the U.S. Navy had seven torpedoes in service use. Three were pre-World War II developments: Mk 13, Mk 14, and Mk 15. Four were developed during the war: Mk 18, Mk 27, Mk 28, and Mine Mk 24. Limited details are given in table 4.

In addition, 15 other types were under development during World War II, largely under the auspices of NDRC. Six were straight running: Mks 16, 17, 19, 20, 25, and 26 (table 5).

The nine homing torpedoes listed in table 6, Torpedoes Mk 21, 22, 29, 30, 31, 32, 33, 34, and 35, were in development at the end of the second World War.

Of the 15 torpedoes listed in tables 5 and 6, six were included in BuOrd post-World War II plans. Of the six that were continued, only three became in-service torpedoes: the submarine-launched, Navol antisurface ship Torpedo Mk 16; the aircraft-launched, active homing ASW Torpedo Mk 32, used as a destroyer-launched ASW weapon; and the aircraft-launched, passive homing ASW Torpedo Mk 34.

INTERIM WEAPONS

The torpedoes listed in table 7 (Torpedoes Mk 27 Mod 4, Mk 32 Mod 2, and Mk 34 Mod 1) were produced in quantity and issued as "interim" weapons to provide an immediate ASW capability. It was recognized, however, that they would soon be replaced by new development: Torpedoes Mk 35, Mk 37 and Mk 43.

MODERN TORPEDO DEVELOPMENT (1950 TO PRESENT)

TORPEDOES MK 35 AND MK 37 DEVELOPMENT

Torpedo Mk 35 was intended to be a universal torpedo, (i.e., aircraft-, submarine-, or destroyer-launched, and used primarily as an antisubmarine weapon with passive/active or combination homing). The aircraft-launch requirement for the torpedo was dropped in 1948.

Table 4. Torpedoes in Service at End of World War II

Designation	Launch Platform	Target Use	Characteristics		Prop. System	Control System
			Physical	Performance		
Torpedo Mk 13	Aircraft	Surface Ship	22.5 inches diameter 161 inches length 2216 pound weight	33.5 knots 6300 yards	Steam Turbine	Air/Gyro
Torpedo Mk 14	Submarine	Surface Ship	21 inches diameter 246 inches length 3209 pounds weight	46.3/31.1 knots 4.5/9 kiloyards	Steam Turbine	Air/Gyro
Torpedo Mk 15	Destroyer	Surface Ship	21 inches diameter 288 inches length 3841 pounds weight	26.5/33.5/45 knots 15/10/6 kiloyards	Steam Turbine	Air/Gyro
Torpedo Mk 18	Submarine	Surface Ship	21 inches diameter 245 inches length 3154 pounds weight	29 knots 4000 yards	Electric Secondary Battery	Air/Gyro
(Torpedo) Mine Mk 24	Aircraft	Submarine	19 inches diameter 84 inches length 680 pounds weight	12 knots 4000 yards	Electric Secondary Battery	Passive Acoustic
Torpedo Mk 27	Submarine	Escort Ship	19 inches diameter 90 inches length 720 pounds weight	12 knots 5000 yards	Electric Secondary Battery	Passive Acoustic
Torpedo Mk 28	Submarine	Surface Ship	21 inches diameter 246 inches length 2800 pounds weight	19.6 knots 4000 yards	Electric Secondary Battery	Passive Acoustic

Table 5. Straight-Running Torpedoes Under Development at End of World War II

Designation	Launch Platform	Target Use	Characteristics		Prop. System	Control System	Status (1950)	Remarks
			Physical	Performance				
Torpedo Mk 16	Submarine	Anti-Surface Ship	21 inches diameter 246 inches length 3920 pounds weight	46 knots 14000 yards	H_2O_2 Alcohol Turbine	Air/ Gyro	Prod./ Devel.	High-speed, long-range, submarine-launched antisurface ship torpedo.
Torpedo Mk 17	Destroyer	Anti-Surface Ship	21 inches diameter 288 inches length 4600 pounds weight	46 knots 1800 yards	H_2O_2 Alcohol Turbine	Air/ Gyro	Devel.	Long-range Mk 16 for destroyer use. Terminated due to emerging D/D ASW role.
Torpedo Mk 19	Submarine	Anti-Surface Ship	21 inches diameter 245 inches length 3154 pounds weight	29 knots 4000 yards	Electric Secondary Battery	Electric Gyro	10 devel. prototypes built and tested	Mk 18 with electric control system in lieu of air.
Torpedo Mk 20	Submarine	Anti-Surface Ship	21 inches diameter 246 inches length	33 knots 3500 yards	Electric Secondary Battery	Gyro	Devel.	Final version of earlier Navy type "EL," Mk 1/ Mk 2 effort. No production due to availability of Mk 18.
Torpedo Mk 25	Aircraft	Anti-Surface Ship	22.5 inches diameter 161 inches length 2306 pounds weight	40 knots 2500 yards	High-Temp. Turbine	Air/ Gyro	Devel.	Development completed at end of WWII. No production.
Torpedo Mk 26	Submarine	Anti-Surface Ship	21 inches diameter 246 inches length 3200 pounds weight	40 knots 6000 yards	Electric Primary SWAB	Electric Gyro	Term.	Contrarotating motor/ propellers, variable running depth. Terminated due to Mk 16.

Table 6. Homing Torpedoes Under Development at End of World War II

Designation	Launch Platform	Target Use	Characteristics		Prop. System	Control System	Status (1950)	Remarks
			Physical	Performance				
Torpedo Mk 21	Guided Missile	Anti-Surface Ship	22.5 inches diameter 161 inches length 216 pounds weight	33.5 knots 630° yards	Steam Turbine	Passive Acoustic Homing	Devel.	Application of Bell Telephone Lab acoustic homing system to the Mk 13 torpedo for use as payload for Petrel missile.
Torpedo Mk 22	Submarine	Anti-Surface Ship	21 inch diameter 246 inches length 3060 pounds weight	29 knots 4000 yards	Electric Secondary Battery	Active Acoustic (Azimuth)	Devel.	Application of active homing to antisurface ship torpedo. Terminated at end of BuOrd evaluation.
Torpedo Mk 29	Submarine	Anti-Surface Ship	21 inches diameter 246 inches length	21/28 knots 12,000/4000 yards	Electric Secondary Battery Acoustic	Electric Gyro Passive	Term. BuOrd Eval.	First application of sea water-activated battery. Improved Mk 28. Deferred due to better Mk 16.
Torpedo Mk 30	Submarine	Anti-Surface Ship	N.A.	N.A.			Devel.	Abandoned as a torpedo development. Continued as homing control system.
Torpedo Mk 31	Destroyer	Anti-Surface Ship	21 inches diameter 246 inches length 3000 pounds weight (approx.)	20/29 knots 4000 yards	Electric Secondary Battery	Passive Acoustic	Term. BuOrd Eval.	Acoustic-steering modification of Mk 18. Contrarotating motor/props. Magnetrostrictive hydrophones, two-speed.
Torpedo Mk 32	Aircraft/ Destroyer	Anti-Submarine	19 inches diameter 93 inches length 805 pounds weight	12 knots 6000 yards	Electric Secondary Battery	Active Acoustic	Prod./ Devel.	First application of echo ranging (active homing) to a torpedo. Limited production (10) WWII. Reactivated 1951 as Mod 2, 3300 produced. Issued to destroyers.
Torpedo Mk 33	Aircraft/ Submarine	Anti-Submarine/ Surface	21 inches diameter 156 inches length 1795 pounds weight	12/18 knots 5000/18,000 yards	Electric Secondary or Primary Battery	Passive Acoustic	Term.	Electrohydraulic controls. Terminated. Features incorporated in Mk 35.

Table 6. Homing Torpedoes Under Development at End of World War II (Cont'd)

Designation	Launch Platform	Target Use	Characteristics		Prop. System	Control System	Status (1950)	Remarks
			Physical	Performance				
Torpedo Mk 34	Aircraft	Submarine	19 inches diameter 124 inches length 1164 pounds weight	12/17 knots 1200/5600 yards	Electric Secondary Battery	Electric Passive Homing	Prod.	Two-speed (search/attack) Mk 24. Speed shift at target acquisition. Devel. complete WWII. 4000 produced 1950's. Issued as aircraft ASW torpedo.
Torpedo Mk 35	Aircraft/ Submarine/ Destroyer	Submarine	21 inches diameter 162 inches length 1560 pounds weight	26 knots 14,000 yards	Electric SWAB	Hyd. Passive Active Homing	Devel.	Intended as universal torpedo. Aircraft req't dropped 1948. Limited production (400) for Fleet use due to adoption of Torpedo Mk 37.

Table 7. Torpedoes Produced as Interim ASW Weapons

Designation	Launch Platform	Target Use	Characteristics		Prop. System	Control System	Remarks
			Physical	Performance			
Torpedo Mk 27 Mod 4	Submarine	Escort Ship	19 inches diameter 125 inches length 1175 pounds weight	16 knots 6200 yards	Electric Secondary Battery	Passive Acoustic	
Torpedo Mk 32	Aircraft/ Destroyer	Anti-Submarine	19 inches diameter 93 inches length 805 pounds weight	12 knots 6000 yards	Electric Secondary Battery	Active Acoustic	First application of echo ranging (active homing) to a torpedo. Limited production (50) WWII. Reactivated 1951 as Mod 2, 3300 produced. Issued to destroyers.
Torpedo Mk 34	Aircraft	Submarine	19 inches diameter 124 inches length 1164 pounds weight	12/17 knots 1200/5600 yards	Electric Secondary Battery	Electric Passive Homing	Two-speed (search/attack) Mk 34 Mk 24. Speed shift at target acquisition. Devel. completed WWII. 4000 produced 1950's. Issued as aircraft ASW torpedo.

To fulfill the aircraft-launch requirement, development of Torpedo Mk 41 was initiated. The Mk 41 was to be a compact version of Torpedo Mk 35, eliminating those features not required for aircraft launching (that is, fire control preset, enable, etc.). A limited number of torpedoes were produced for evaluation, but Torpedo Mk 41 was discontinued in favor of the Torpedo Mk 43 type.

Torpedo Mk 37 was also being developed as a parallel effort with the Mk 35. The main differences between the Mk 35 and Mk 37 were hull construction and homing systems. The Mk 37 torpedo, with a welded aluminum hull vice aluminum castings for the Mk 35, was being developed around the Harvard Underwater Sound Laboratory/Ordnance Research Laboratory (HUSL/ORL) Project 4 homing panel which required target motion to satisfy a Doppler enabler circuit to establish attack conditions. This feature was to provide protection against homing on false targets such as surface or bottom. Although limited numbers of Mk 35's were produced and issued to the Fleet, the Mk 37 was selected for quantity production and became the standard submarine post-World War II weapon. At one point, Torpedo Mk 37 was also issued to destroyers, but was ultimately withdrawn from that application with the availability of the lightweight ASW torpedoes and Torpedo Tube Mk 32.

THE LIGHTWEIGHT ASW TORPEDO

Development of aircraft-launched torpedoes in the World War II/early post-World War II era, followed the classic envelope (i.e., 21/22-inch diameter, 1000-pound plus warshot weight). Torpedoes Mk 25, Mk 35, Mk 40, and Mk 41 (a stripped-down Mk 35) all fit that mold, which was more suited to a strike warfare mission than the emerging ASW role for Naval aircraft.

At the end of World War II, it was envisioned that future convoys would be protected from submarine attack by helicopter with dunking sonar and/or LTA (lighter than air) airships with towed sonar. For this application, light weight become a primary consideration for the weapon, and in addition, since such a system might require large numbers of torpedoes, cost was also an important factor. Thus, in the early post-World War II years, the Navy's requirement for a lightweight, low-cost, ASW torpedo was evolved.

In 1950, the maximum weight for the lightweight ASW torpedo was set at 350 pounds with the realization that when compared with Torpedoes Mk 35 and Mk 41 (which was in development at that time), it would not be possible to attain the same performance characteristics. However, the same type of homing system used in the Mk 35 and the Mk 41 (active acoustic) might be employed accepting a degradation in speed and range performance. The feasibility of developing a torpedo of this type had been successfully demonstrated by Mine Mk 30 in 1943.

Against this background, the development of the Torpedo Mk 43 type was initiated. This development held the possibility of not only yielding an ASW torpedo for use from helicopters and LTA aircraft, but also for use from any type of patrol craft against slow or quiet submarines.

Two torpedoes of the Mk 43 type were developed concurrently: the Mod 0 by General Electric Co., Aeronautical and Ordnance Systems Div., Pittsfield, Mass.; and the Mod 1 by Brush Development Co., Cleveland, Ohio. Both were electrically-propelled, had active acoustic homing systems, and were well under the maximum weight specification of 350 pounds. Torpedo Mk 43 Mod 1 was selected for further development, production, and ultimate Fleet use with technical direction assigned to the Naval Ordnance Test Station (NOTS), Pasadena, Calif.

Torpedo Mk 43 Mod 1 established the new look for aircraft and destroyer ASW torpedoes. It was significant in the successful development of the lightweight ASW torpedo, since this torpedo obviated the need for a special torpedo plane. Its size and weight were such that the torpedo was readily adaptable to the bomb bays or external stations of virtually any aircraft with bomb-carrying capability.

The next generation of lightweight ASW torpedoes evolved from the EX-2 concurrent development program which started about 1952; the EX-2A was developed at NOTS, Pasadena, while the EX-2B was developed at the General Electric Co., Pittsfield, Mass.

In general, these acoustic homing torpedoes were designed to weigh less than 450 pounds, be reasonably inexpensive (less than $10,000 each in production), with the speed, range/endurance and homing capability to be effective against the modern deep-diving submarine target (of that time). These torpedoes were also to be capable of being launched from rotary/fixed wing or LTA aircraft and surface ships.

The two versions of the EX-2 (both electrically-propelled) that emerged from the development program were very similar as shown in table 8.

Table 8. Characteristics of EX-2 Torpedoes

Characteristic	EX-2A	EX-2B
Weight (Warshot)	415 pounds	445 pounds
Length	98.5 inches	100 inches
Diameter	12 inches	12.75 inches
Exploder	Mk 19	Mk 19
Propellers		
Number (Contrarotating)	2	2
Number Blades	3	4
Battery Type	Silvercel	Sea Water
Motor	22 hp	30 hp
Contrarotating Motor	Yes	No
Gear Box	No	Yes
Acoustic System	Passive-Acoustic	Active
Speed	Equal	
Range	Equal	
Operating Depth	Equal	

After the Bureau of Ordnance technically evaluated both versions at the Naval Ordnance Unit (NOU), Key West, Fla., in the fall of 1956, the EX-2B was selected for further development, production, and Fleet use. The EX-2B was designated Torpedo Mk 44 with technical direction for the program assigned to NOTS, Pasadena.

In 1956, development of the Mk 44 was completed and production of units for Fleet use commenced. This second generation, lightweight ASW torpedo began to replace Torpedo Mk 43 Mods 1 and 3 as the in-service aircraft/surface-launched ASW torpedo. In the surface launch application, the Mk 44 was also adopted as the missile payload for rocket launching in the ASROC missile system and was the torpedo payload when that system became operational in Fleet units about 1962.

Initially, torpedoes were the driving factor in submarine development as a torpedo launching platform. With rapid advances in submarine development, the roles were reversed. The high-speed, deep-diving, quiet, highly-maneuverable submarine as a potential threat provided the impetus for the development of another generation of the lightweight ASW torpedo, the Mk 46 Mod 0.

Development of the Torpedo Mk 46 Mod 0 started about 1958 to provide an improved lightweight torpedo to increase the kill capability and reduce the necessity for salvo fire. After competitive bidding by 14 contractors, a contract was given to Aerojet General Corp., Azusa, Calif. The Pacific Div. of the Bendix Corp. was designated by Aerojet as the principal subcontractor for the development and fabrication of the electronics systems. NOTS, Pasadena, was designated techical director for this program.

The torpedo that resulted from the development was the first to use the hot gases developed by burning a solid grain propellant to power a swash plate engine (a type of reciprocating engine) for propulsion. Concurrently, accessories were developed to permit launching the torpedo from aircraft at speeds up to 500 knots. Development was completed and production of Torpedo Mk 46 Mod 0 started in 1963.

The use of solid propellant, although providing the desired propulsion characteristics, created maintenance problems. Consequently in 1962, studies began seeking to improve the propulsion system of Torpedo Mk 46 Mod 0, with the end objective being to develop a Mod 1 version. Of the two primary systems under consideration, seawater battery electric propulsion and liquid fuel monopropellant cam engine, the cam engine system was selected. The end result was a torpedo that was lighter, and had improved propulsion characteristics and a higher reliability. Much of the Mod 0 configuration was retained in the Mod 1 including the guidance system, warhead, exploder, and launching accessories.

In the continuing development of Torpedo Mk 46, the Mod 2 was developed to provide helicopter attack torpedo system (HATS) capability. Prior to the

introduction of HATS, helicopter ASW tactics required the use of two helicopters in a coordinated attack; one to detect the target and vector the second helicopter to launch position along the target bearing.

By the use of HATS, new course control circuitry that allowed a wider selection of the initial course of the torpedo after water entry permitted one helicopter to detect the target and also to launch the torpedo while hovering into the wind, regardless of the target's bearing.

The Torpedo Mk 46 type is the lightweight ASW torpedo currently in service use.

Within ten years of World War II, phase out of in-service weapons of World War II or early post-World War II vintage was under way as follows:

1. Torpedo Mk 13 - declared obsolete, scrapped,

2. Torpedo Mk 14 - scheduled for replacement by Mk 16,

3. Torpedo Mk 15 - to be scrapped as above-water tubes were removed from destroyers,

4. Torpedo Mk 16 - designated service weapon.

5. Torpedo Mk 18 - scrapped,

6. Torpedo Mk 21 - designated payload for Petrel missile,

7. Torpedo Mk 23 - scrapped, later some converted to Mk 14, some cannibalized for Mk 14 spare parts,

8. Torpedo Mine Mk 24 - replaced by Mk 34 Mod 1,

9. Torpedo Mk 27 Mod 0 - replaced by Mk 27 Mod 4,

10. Torpedo Mk 27 Mod 4 - to be replaced by Mk 37 Mod 0,

11. Torpedo Mk 28 - to be replaced by Mk 37 Mod 0,

12. Torpedo Mk 32 - to be replaced by Mk 43,

13. Torpedo Mk 37 - designated service weapon,

14. Torpedo Mk 39 - designated experimental wire guidance development,

15. Torpedo Mk 43 - designated service weapon.

When these adjustments had been completed, the U.S. Navy service inventory of torpedo types was as follows:

1. Submarine torpedoes - Mk 14, Mk 16, Mk 37,

2. Destroyer torpedoes - Mk 43, Mk 37,

3. Aircraft torpedoes - Mk 43.

ASW STANDOFF WEAPON DEVELOPMENT

Interest in providing surface ships with a "standoff" or "thrown torpedo" capability began in the early post-World War II period. The principal advantage of the thrown torpedo (projected through the air) was the substantial increase in range. A long-range weapon would enable attacks to be made at maximum sonar detection range. Ability to attack at long ranges would provide tactical flexibility and would permit the surface ship to take offensive action against a submarine before the submarine would be likely to launch its own attack against the surface ship. Indications are that a feasibility study relative to increasing the range of existing ASW weapons by use of rocket projection was initiated at the Naval Ordnance Test Station (NOTS) about 1950, with Mine Mk 24 as the weapon under consideration. Test vehicle firings in 1952/1953 were highly successful.

In 1953, initial success led to the Rocket-Assisted Torpedo (RAT) program, with more advanced ASW torpedoes of the Torpedo Mk 43 type as a payload. The RAT system was initially developed with Torpedo Mk 43 Mod 0 as the payload. However, when production of Torpedo Mk 43 Mod 0 was discontinued, the program was redirected using a Torpedo Mk 43 Mod 1. RAT demonstrated the feasibility of the thrown torpedo as an effective ASW system.

An extension of the weapon delivery technique developed in the RAT program, the ASROC weapon system development began in 1956 with technical direction assigned to NOTS, and as prime contractor, the Minneapolis-Honeywell Regulator Company Ordnance Division, Hopkins, Minn. The ASROC weapon system with multicell launcher, associated fire control, and a missile employing Torpedo Mk 44 as a payload was introduced as a service weapon system about 1962 (figure 19). The system now employs Torpedo Mk 46 as a missile payload. The ASROC system is widely deployed in cruisers, destroyers, and other escort-type ships (figure 20).

A FINAL WORD ON TORPEDOES MK 14 AND MK 16

Torpedo Mk 16 continued in development through the mid-1960's, and after a series of modifications, emerged in its final configuration as Torpedo Mk 16 Mod 8. The majority of the inventory was modified to this configuration and was used as a service weapon until phased withdrawal from service use began in 1975.

It is of interest to note that Torpedo Mk 14, a development of the 1930's, and the primary submarine-launched torpedo of World War II, was declared obsolete in the late 1950's or early 1960's, but was reactivated in 1969 and is still in service use.

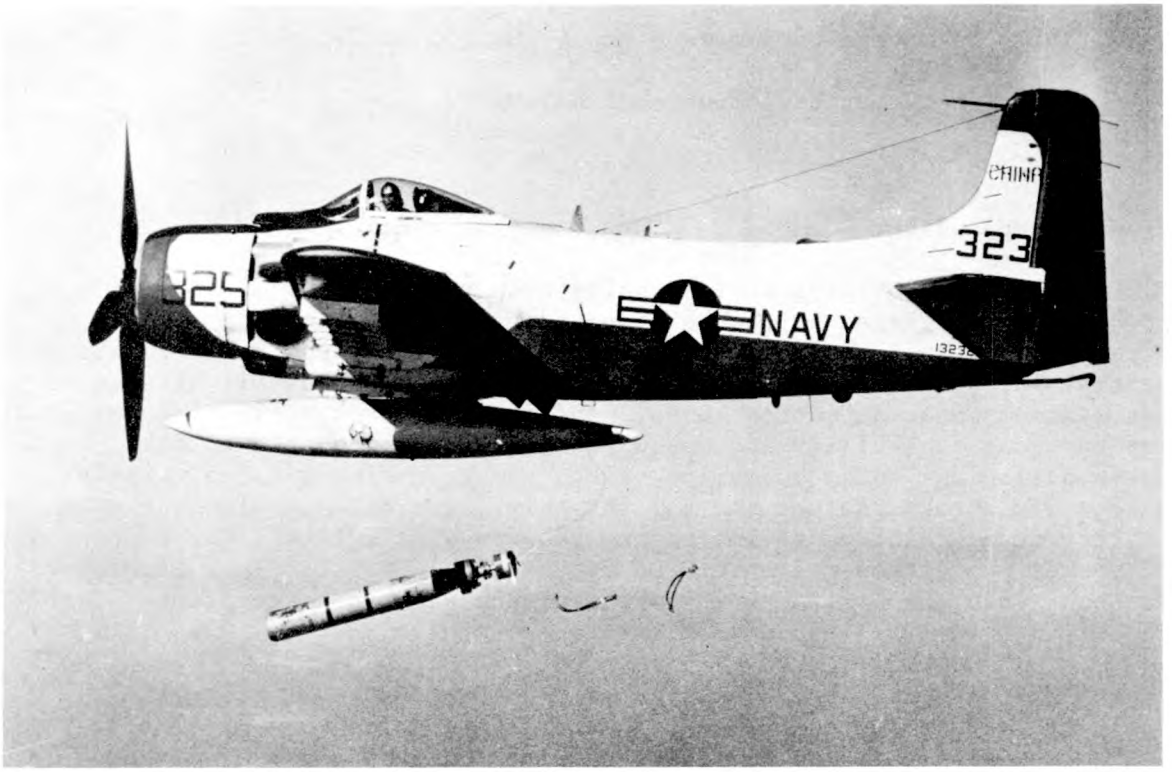


Figure 19. AD 4 Aircraft Launching Torpedo Mk 44

WIRE GUIDANCE AS A TORPEDO CONTROL SYSTEM

Torpedo Mk 39, whose status was changed from a torpedo development to a homing control system development in the post-World War II period, re-emerged in 1956 with the conversion of approximately 120 Torpedoes Mk 27 Mod 4 to Torpedo Mk 39. Its purpose was familiarization and further development of wire guidance techniques.

Wire guidance as a control system was incorporated in the development of Torpedo Mk 45. A high-speed, long-range, submarine-launched torpedo with a nuclear warhead, it featured high reliability resulting from stringent quality standards applied to its manufacture. With quantity production starting about 1960, this was the first submarine-launched torpedo to successfully employ a seawater-activated battery in service use. Torpedo Mk 45 has recently been phased out of service use.

Follow-on development of Torpedo Mk 37 resulted in a version incorporating the wire guidance feature. Originally designated Torpedo Mk 37 Mod 1 and later redesignated the Mod 2, it was produced in quantity starting about 1962. Both the wire-guided Torpedo Mk 37 Mod 2 and nonwire-guided Torpedo Mk 37 Mod 3 are currently in service use.

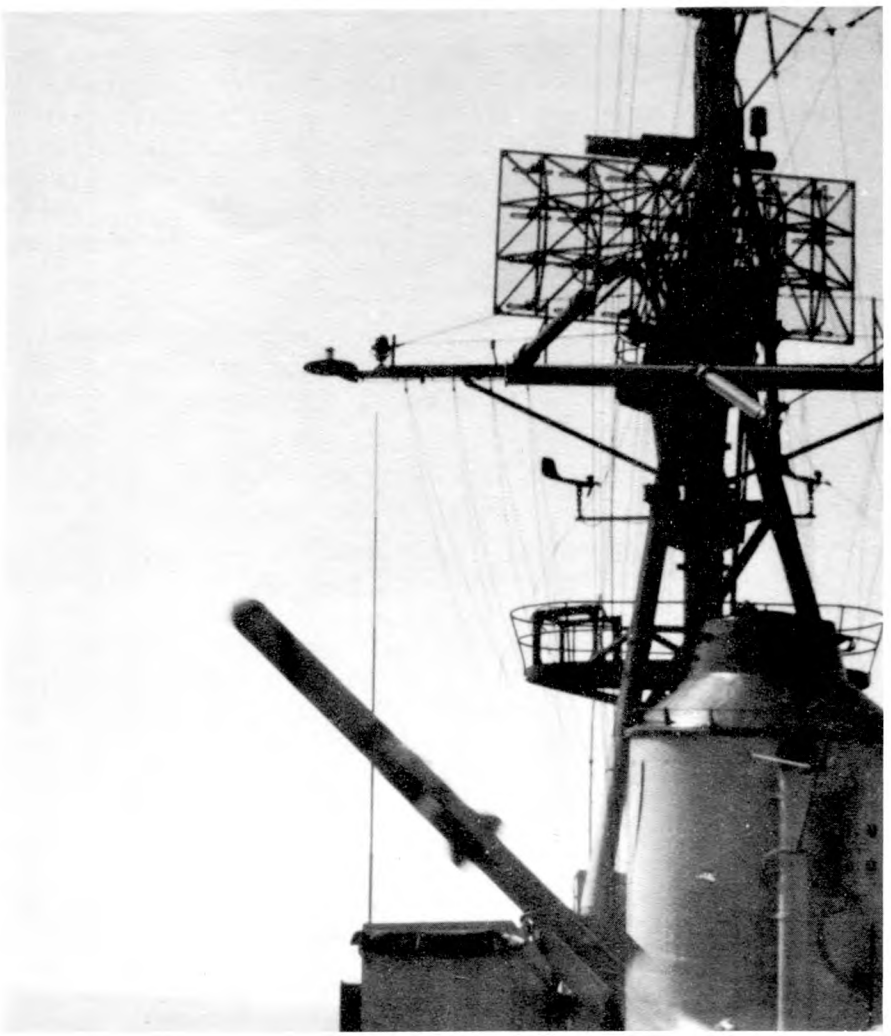


Figure 20. ASROC Being Launched from Destroyer

The development of Torpedo Mk 38, a 21-inch diameter, submarine-launched, antisurface ship torpedo with electric propulsion (primary battery) and active/passive acoustic homing, had been planned for the post-World War II era, but was deferred pending the outcome of Torpedo Mk 37 development. With the successful development of the Mk 37, the need for Torpedo Mk 38 was nullified.

PATTERN-RUNNING TORPEDO DEVELOPMENT (TORPEDO MK 42)

The success of the pattern-running torpedoes employed by Germany in World War II led to the initiation of the development of Torpedo Mk 42. Launched from a submarine or a destroyer against surface targets, this torpedo was to have a 20,000-yard range at 40 knots and a pattern-running control that would provide for any desired zigzag course by electrically presetting

six functions, three ranges and three gyro angles. In an effort to consolidate into one torpedo past experience on the development of various components, responsibility was divided among five activities: the Naval Ordnance Test Station; the Naval Ordnance Laboratory; the Naval Underwater Ordnance Station (formerly the Naval Torpedo Station in Newport); the Ordnance Research Laboratory; and the Stevens Institute of Technology. Fragmentation of responsibility did little to enhance the program, for it was terminated in 1952 in favor of further development of Torpedo Mk 16.

Torpedo Mk 47 was to have been a modern, submarine-launched, high-speed, long-range, antisurface ship torpedo using either thermal or electric propulsion. The development was terminated at the outset due to the status of Torpedo Mk 48.

TORPEDO MK 48

Torpedo Mk 48 is a long-range, high-speed, deep-depth, wire-guided, acoustic homing weapon for detecting and attacking surface ships and fast, deep-diving submarines.

Development of Torpedo Mk 48 Mod 0 started in 1963 as an outgrowth of the NAVORD sponsored RETORC II program with Westinghouse Electric Corp., Baltimore, Md., as prime contractor. This weapon used a turbine propulsion system and an acoustic homing system developed by the Ordnance Research Laboratory at Pennsylvania State University. Torpedo Mk 48 Mod 2 was the ultimate product of this development program.

Concurrent development of the Torpedo Mk 48 Mod 1 with an improved acoustic homing system, employing a piston engine propulsion system began in 1967, with the Clevite Division of Gould, Inc., as prime contractor. Following evaluation of the two versions, Torpedo Mk 48 Mod 1 was selected in 1971 for production and ultimate Fleet use.

Torpedo Mk 48 signals the translation of the existing "state-of-the-art" technology into a production entity in the U.S. Navy torpedo inventory. Follow-on development of the Torpedo Mk 48 is a continuing process. A Mod 3 version with improved mid-course guidance is currently being produced.

Figure 21 is an actual photograph of 100 years of torpedo development. The larger torpedo is Torpedo Mk 48, circa 1971, while the smaller version was developed in 1870, the "Fish" Torpedo.

Part 2, which follows, contains greater physical and configuration details of the various torpedoes discussed in this section while a chronological list of events will given in appendix A. Appendix B presents a list of the former and current identities of the developers and producers of the modern torpedo.

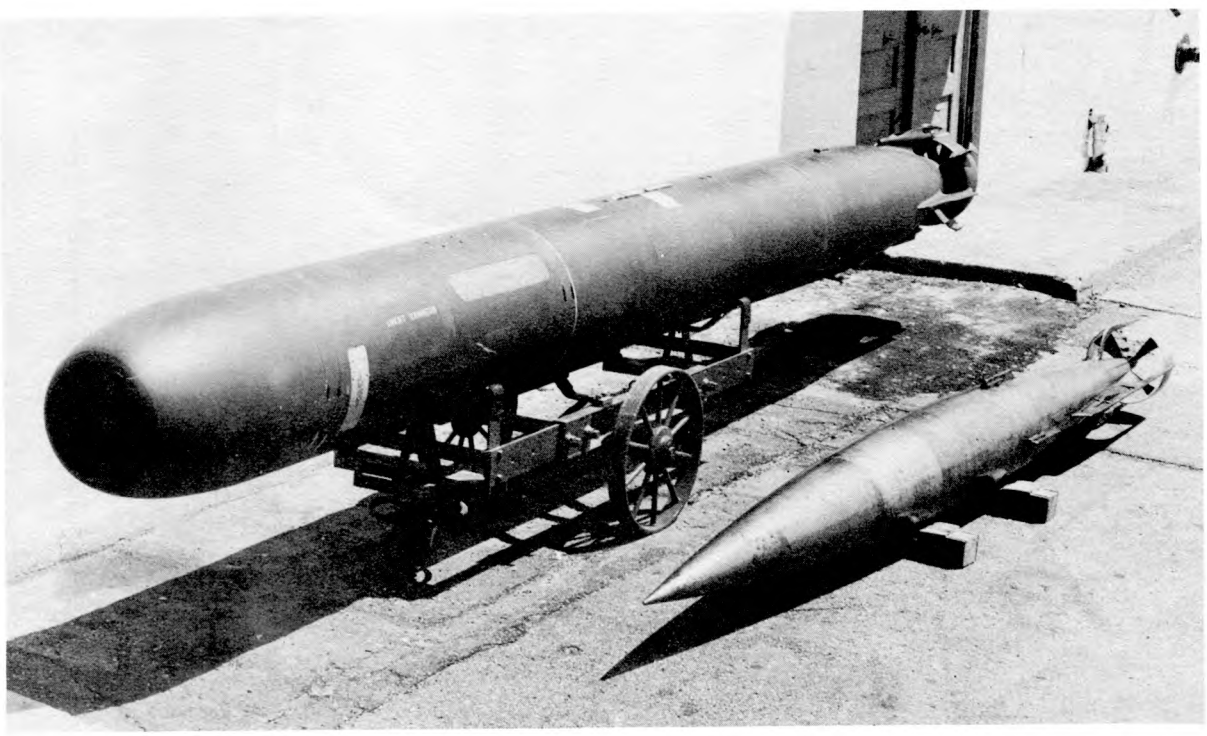


Figure 21. One Hundred Years of U.S.N. Torpedo Development

PART 2

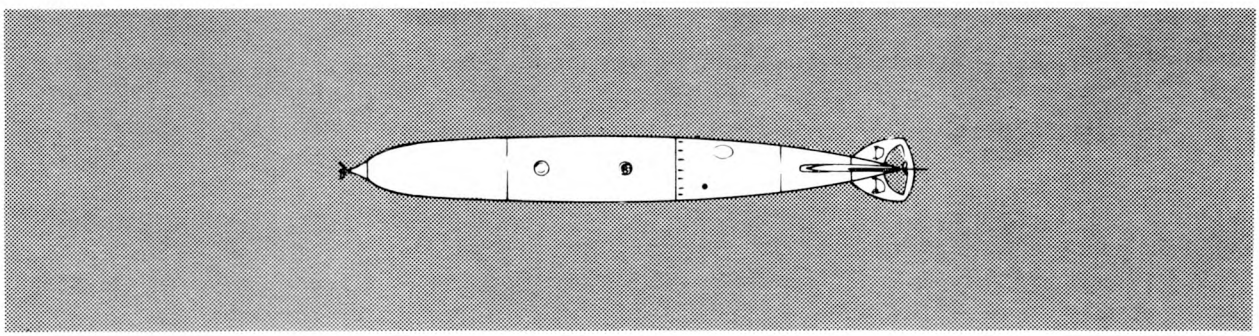
DETAILED DESCRIPTION OF TORPEDOES

Note: Characteristics given are for warshot torpedoes. Weights indicated for these torpedoes include warhead fuel, etc.

Howell Torpedo

DEVELOPMENT DATE:
CIRCA 1880

APPROXIMATE IN-SERVICE DATES:
1890-1898



The Howell Torpedo was named for its inventor, U.S. Navy LCDR John A. Howell. (He later became a Rear Admiral.) This torpedo was the only U.S. torpedo of its era (circa 1880) to attain enough success to be produced in quantity. The power for the Howell was received from a flywheel prespun before launch. In 1889, the U.S. Navy ordered 50 Howell Torpedoes from the Hotchkiss Ordnance Co., Providence, R.I., who had purchased the rights to the torpedo from Howell. This torpedo was used as an antisurface ship, battleship- and torpedo boat-launched weapon until 1898 when it was supplanted by the Whitehead Torpedo. An actual photograph of the Howell is shown on page 17.

CHARACTERISTICS

PHYSICAL

Length	132 inches
Diameter	14.2 inches
Weight	580 pounds
Propulsion	Prespun flywheel
Enabling	No
Guidance	Gyro effect of the flywheel
Homing	No
FC Settings	None
Warhead	100 pounds wet guncotton
Exploder	Contact device

PERFORMANCE

Speed	= 25 knots
Range	400 yards (800 when flywheel runs down)

Whitehead Torpedo Mk 1

DEVELOPMENT DATE:
CIRCA 1892

APPROXIMATE IN-SERVICE DATES:
3.55 M 1894-1913, 5 M 1894-1922

Early accounts indicate that there were two versions of the Whitehead Torpedo Mk 1: a 3.55-meter (140-inch) version and a 5-meter (197-inch) version. The longer Mk 1 carried nearly twice the explosive charge (220 pounds) of the short version and was fitted with the Obry steering gear (gyro control in azimuth). The Whitehead Mk 1 (both lengths) was a "cold" running torpedo; the three-cylinder reciprocating engine ran on cold, compressed air which was stored in a section of the torpedo called the air flask. The E. W. Bliss Co., Brooklyn, N.Y., was the manufacturer of this torpedo for the U.S. Navy. It was used as an antisurface ship, battleship- and torpedo boat-launched weapon.

CHARACTERISTICS

PHYSICAL

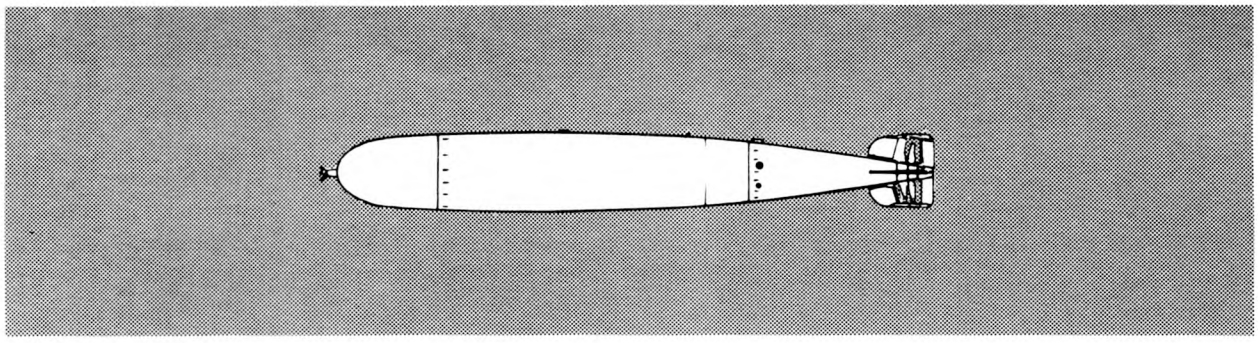
	3.55 M	5 M
Length	140 inches	197 inches
Diameter	17.7 inches	17.7 inches
Weight	845 pounds	1160 pounds
Propulsion	3-cylinder reciprocating	3-cylinder reciprocating
Enabling	No	No
Guidance	Depth control	Depth control, gyro
Flask Air Pressure	1350 psi	1350 psi
Homing	No	No
FC Settings	Preset	Preset
Warhead	118 pounds wet guncotton	220 pounds wet guncotton
Exploder	War Nose Mk 1* Contact	War Nose Mk 1* Contact

PERFORMANCE

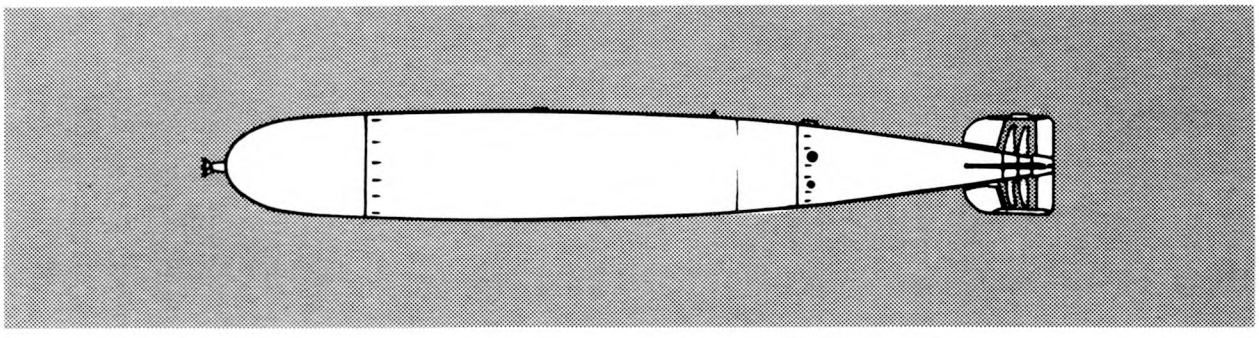
Speed	26.5 knots	27.5 knots
Range	800 yards	800 yards

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Whitehead Torpedo Mk 1 (3.55 meter)



Whitehead Torpedo Mk 1 (5 meter)



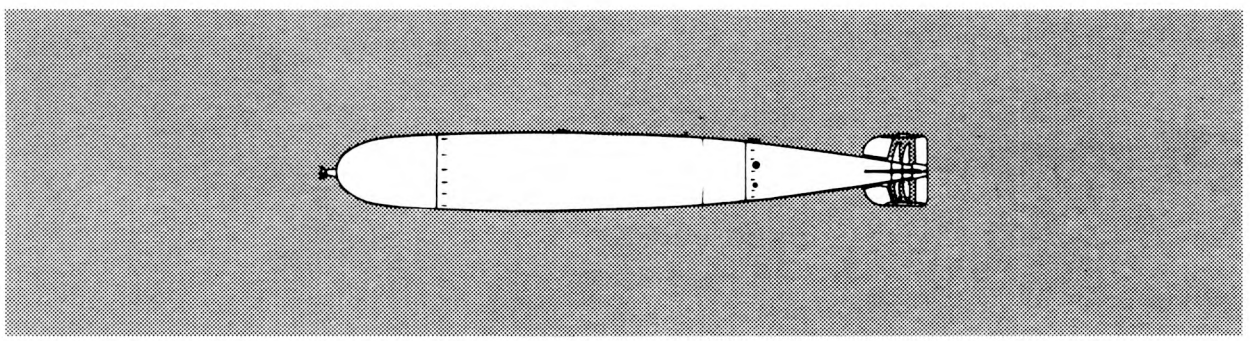
Whitehead Torpedo Mk2

DEVELOPMENT DATE:
CIRCA 1893

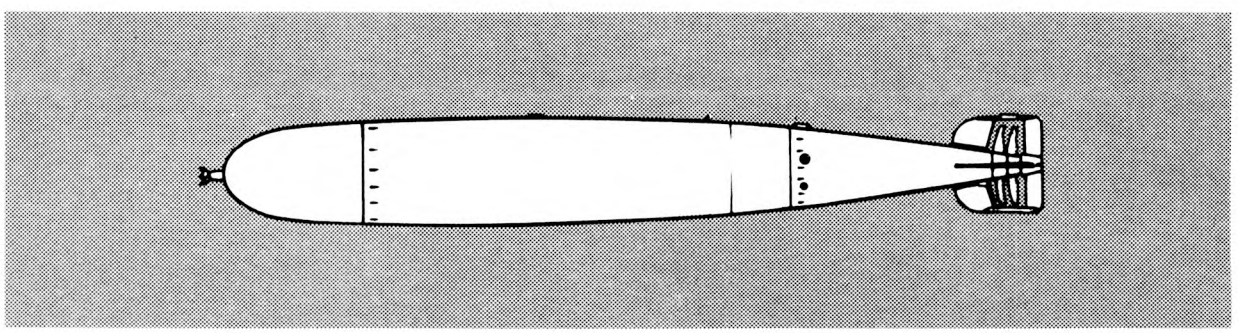
APPROXIMATE IN-SERVICE DATES:
3.55 M 1896-1913, 5 M 1897-1922

There were two versions of the antisurface ship Whitehead Torpedo Mk 2; one was 3.55 meters (140 inches) in length while the second was 5 meters (197 inches) long. Both versions were 45 centimeters (17.7 inches) in diameter. The 5-meter Mk 2 had twice the range of the 3.55-meter Mk 2 (1500 yards versus 800 yards) and had a 10-percent increase in explosive charge (132 pounds versus 118 pounds). The 5-meter Mk 2 was probably based on the 5-meter Mk 1 rather than being a modification of the 3.55-meter Mk 2. This latter torpedo was identical to the 3.55-meter Mk 1 except for mechanical details. For the 5-meter Mk 2 within the 5-meter Mk 1 envelope, the capacity of the air flask was increased by 20 percent and the air flask pressure was increased from 1350 psi to 1500 psi. The launch platforms were battleships and torpedo boats.

Whitehead Torpedo Mk 2 (3.55 meter)



Whitehead Torpedo Mk 2 (5 meter)



CHARACTERISTICS

PHYSICAL

	3.55 M	5 M
Length	140 inches	197 inches
Diameter	17.7 inches	17.7 inches
Weight	845 pounds	1232 pounds
Propulsion	3-cylinder reciprocating	3-cylinder reciprocating
Enabling	No	No
Guidance	Depth control	Depth control
Flask Air Pressure	1350 psi	1500 psi
Homing	No	No
FC Settings	Preset	Preset
Warhead	118 pounds wet guncotton	132 pounds wet guncotton
Exploder	War Nose Mk 1* Contact	War Nose Mk 1* Contact

PERFORMANCE

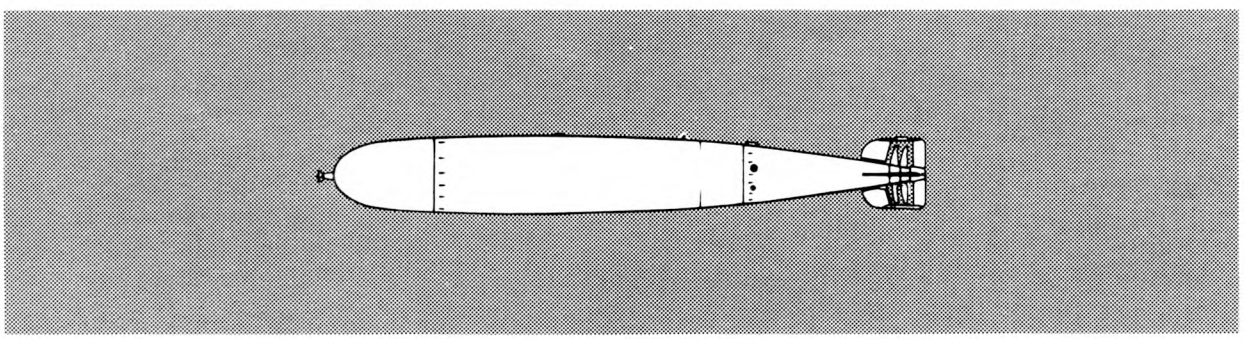
Speed	27 knots	28.5 knots
Range	800 yards	1500 yards

*War Nose Mk 1, Mk 2, and Mk 5 were used interchangeably.

Whitehead Torpedo Mk3

DEVELOPMENT DATE:
CIRCA 1893

APPROXIMATE IN-SERVICE DATES:
3.55M 1898-1922



Unlike Whitehead Torpedoes Mk 1 and Mk 2, there was only one version of the Whitehead Mk 3 torpedo, the 3.55-meter. The main difference between the 3.55-meter Whitehead Mk 3 and the previous versions of this length was the inclusion of the Obry steering gear (gyro) for azimuth control. According to U.S. Navy acceptance tests for the Whitehead type torpedo, the maximum deviation right or left of the target was reduced from 24 to 8 yards in the Whitehead Mk 3. About 100 Torpedoes Mk 3 were purchased from the E. W. Bliss Co., and in 1913, redesignated Torpedo Type A. The Whitehead Torpedo Mk 3 was withdrawn from service use in 1922 when all torpedoes designed prior to Torpedo Mk 7 were condemned in favor of more modern weapons.

CHARACTERISTICS

PHYSICAL

Length	140 inches
Diameter	17.7 inches
Weight	845 pounds
Propulsion	3-cylinder reciprocating
Enabling	No
Guidance	Gyro
Flask Air Pressure	1350 psi
Homing	No
FC Settings	Preset
Warhead	118 pounds wet guncotton
Exploder	War Nose Mk 1* Contact

PERFORMANCE

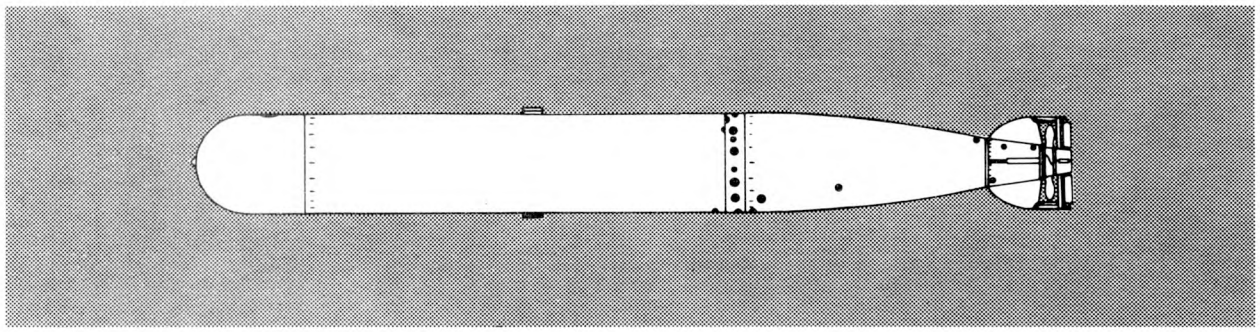
Speed	26.5 knots
Range	800 yards

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk 1

DEVELOPMENT DATE:
1904

APPROXIMATE IN-SERVICE DATES
1904-1922



After the E.W. Bliss Co. had manufactured Whitehead Torpedoes for several years, one of the company's engineers, F. Leavitt, developed a turbine-driven antisurface ship torpedo which was designated the Bliss-Leavitt Torpedo Mk 1. In addition to the engine change, the air flask pressure of the new weapon was increased to 2250 psi (vice 1500 psi for the Whitehead units). The air in the new model was heated by burning alcohol in a chamber upstream from the engine. The increased air flask pressure and heated air served to increase the range of the Bliss-Leavitt Mk 1 to 4000 yards at 27 knots. (The range was 1500 yards at 28.5 knots for the 5-meter Whitehead Mk 2.) This torpedo, in service on battleships, torpedo boats, and cruisers, used a single vertical turbine wheel rotating about the torpedo's longitudinal axis and driving a single propeller. The unbalanced torque was sufficient to cause the Mk 1 to have a tendency to roll.

CHARACTERISTICS

PHYSICAL

Length	197 inches
Diameter	21 inches
Weight	$\cong$ 1500 pounds
Propulsion	Single vertical turbine wheel
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Preset
Warhead	$\cong$ 200 pounds wet guncotton
Exploder	War Nose Mk 1* Contact

PERFORMANCE

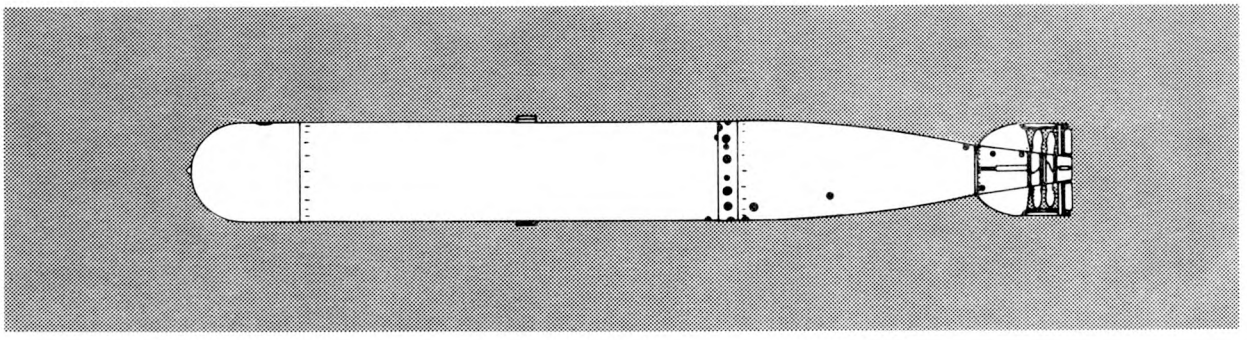
Speed	27 knots
Range	4000 yards

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk2

DEVELOPMENT DATE:
1905

APPROXIMATE IN-SERVICE DATES:
1905-1922



The Bliss-Leavitt Torpedo Mk 2 was a "hot running" (propelled by heated air), 21-inch (in diameter) torpedo used on battleships, torpedo boats, and cruisers. This antisurface ship torpedo, developed by the E.W. Bliss Co., Brooklyn, N.Y., was the first weapon to use two contrarotating turbines with each driving a propeller. The development eliminated the unbalanced torque which had contributed to the tendency of the Bliss-Leavitt Mk 1 to roll. About 250 units were manufactured by the E.W. Bliss Co. for the U.S. Navy.

CHARACTERISTICS

PHYSICAL

Length	197 inches
Diameter	21 inches
Weight	≅ 1500 pounds
Propulsion	Turbine (contra-rotating)
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Preset
Warhead	≅ 200 pounds wet guncotton
Exploder	War Nose Mk 5* Contact

PERFORMANCE

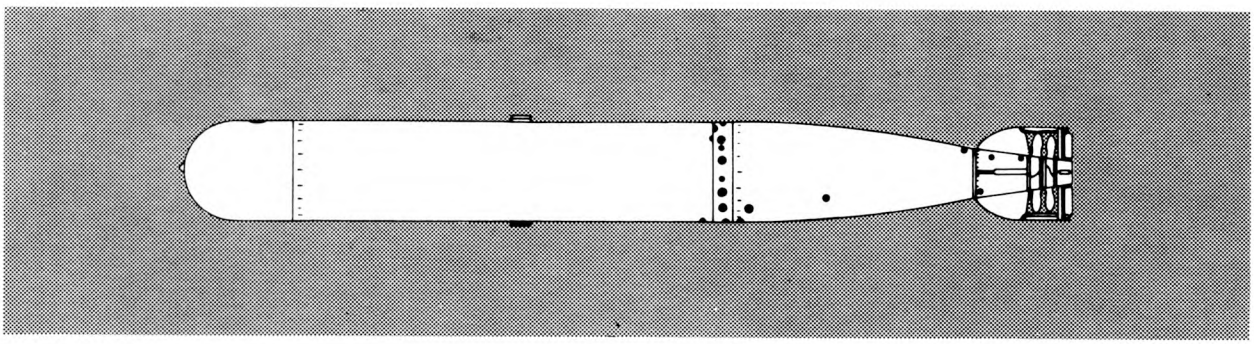
Speed	26 knots
Range	3500 yards

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk3

DEVELOPMENT DATE:
1906

APPROXIMATE IN-SERVICE DATES:
1906-1922



Developed and manufactured by the E.W. Bliss Co., Brooklyn, N.Y., the Bliss-Leavitt Torpedo Mk 3 was very similar to the Bliss-Leavitt Mk 2. This torpedo was a "hot running," 21-inch (in diameter) antisurface ship torpedo used on battleships, torpedo boats, and cruisers. The main difference between Mk 2 and Mk 3 was that the Mk 3 had an increased range (4000 yards versus 3500 yards for Mk 2). Approximately 200 Bliss-Leavitt Torpedoes Mk 3 were produced for the U.S. Navy.

CHARACTERISTICS

PHYSICAL

Length	197 inches
Diameter	21 inches
Weight	≅ 1500 pounds
Propulsion	Turbine (contra-rotating)
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Preset
Warhead	≅ 200 pounds wet guncotton
Exploder	War Nose Mk 5* Contact

PERFORMANCE

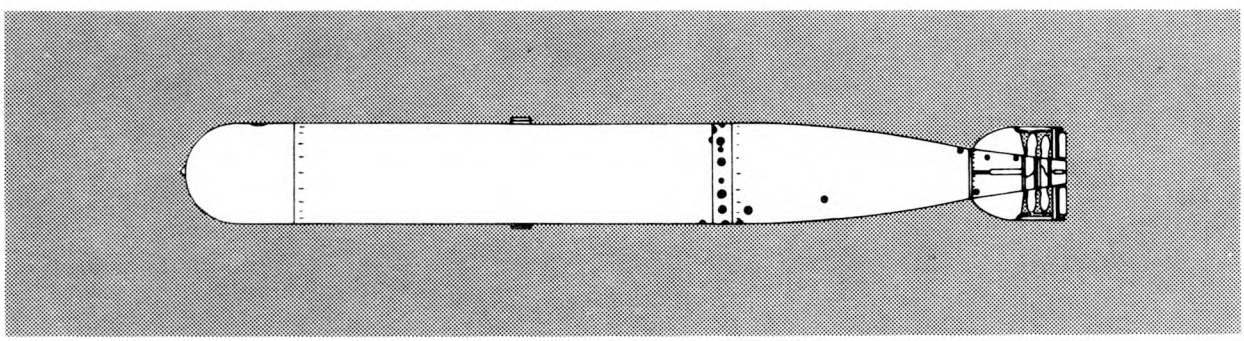
Speed	26 knots
Range	4000 yards

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk4

DEVELOPMENT DATE:
1908

APPROXIMATE IN-SERVICE DATES:
1908-1922



The Bliss-Leavitt Torpedo Mk 4, an 18-inch antisurface ship weapon, was the first torpedo specifically designed for submarine launching. (Earlier torpedoes were used on battleships and cruisers.) Developed and produced by the E.W. Bliss Co., about 100 of these units were purchased by the U.S. Navy for experimental purposes. The experiments with the Bliss-Leavitt Torpedo Mk 4 led to design improvements to the gyro and the reducing valve. In 1922, the torpedo and all other torpedoes designed prior to Torpedo Mk 7, were considered obsolete and withdrawn from service use.

CHARACTERISTICS

PHYSICAL

Length	197 inches
Diameter	17.7 inches
Weight	≅ 1500 pounds
Propulsion	Vertical turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Preset
Warhead	Info not available
Exploder	War Nose Mk 1*

PERFORMANCE

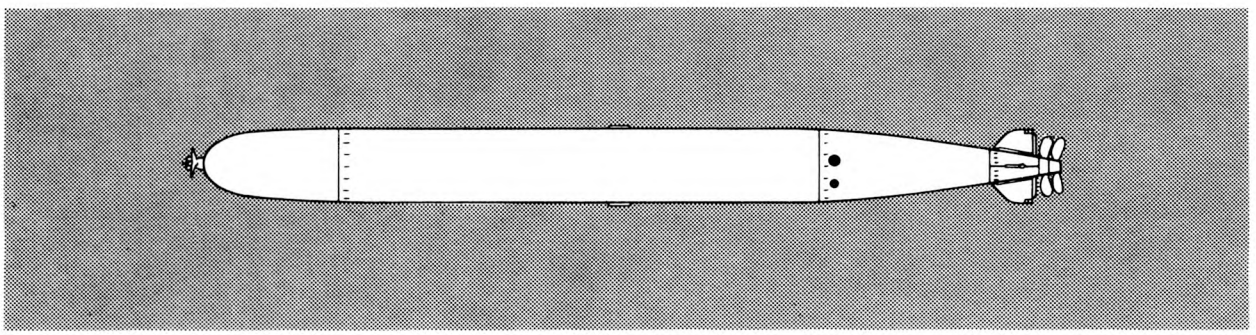
Speed	Info not available
Range	Info not available

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Whitehead Torpedo Mk5

DEVELOPMENT DATE:
CIRCA 1901

APPROXIMATE IN-SERVICE DATES:
1910-1922



A "hot running" (powered by heated air) torpedo of Whitehead design, the Mk 5 torpedo was the first torpedo to be manufactured by the Naval Torpedo Station in Newport, R.I. (1908). The Mk 5 was similar in performance to the Bliss-Leavitt torpedoes of that era, and approximately 500 units were produced by the Torpedo Station and Vickers Ltd. of England. This torpedo was doomed, however, by a major technological advancement (increased efficiency and range) in the Bliss-Leavitt Torpedo Mk 7 which came soon after the Mk 5 was produced. The Mk 5 was the first to permit the firing ship to vary speed and range. The Mk 5 was accomplished by adjustment of the reducing valve prior to tube loading. The Mk 5 was used on battleships, torpedo boats, and submarines, and was an antisurface ship weapon.

CHARACTERISTICS

PHYSICAL

Length	204 inches
Diameter	17.7 inches
Weight	1452 pounds
Propulsion	4-cylinder reciprocating
Enabling	No
Guidance	Gyro
Flask Air Pressure	2100 psi
Homing	No
FC Settings	Preset
Warhead	200 pounds wet guncotton
Exploder	War Nose Mk 5* Contact

PERFORMANCE

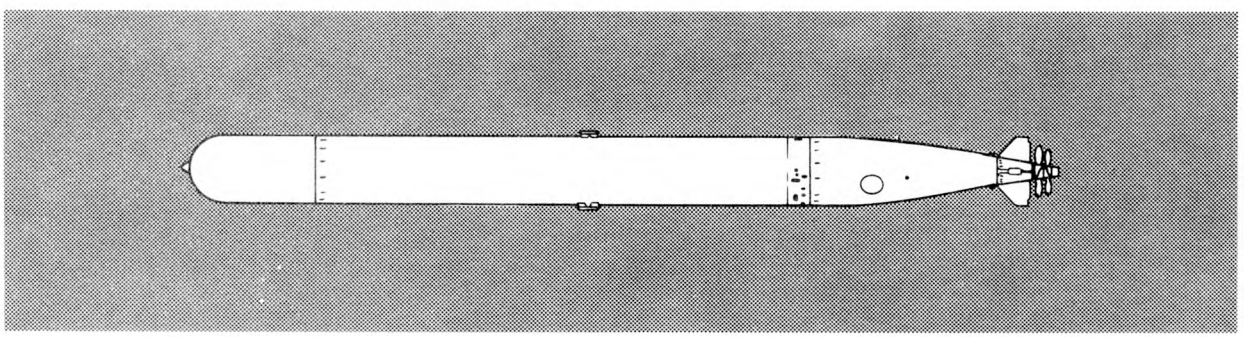
Speed (knots)	
Low	27
Medium	36
High	40
Range (yards)	
Low	4000
Medium	2000
High	1000

*War Noses Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk6

DEVELOPMENT DATE:
1911

APPROXIMATE IN-SERVICE DATES:
1911-1922



The Bliss-Leavitt Torpedo Mk 6 was an 18-inch antisurface ship torpedo designed for above-water tubes and could be launched from destroyers and cruisers. It featured a main engine that was a horizontal turbine rather than the vertical turbine used on all other Bliss-Leavitt torpedoes. The Mk 6 depth and gyro controls were also combined into one unit as another design change. Although the Mk 6 torpedo reached speeds up to 35 knots, its range was conversely reduced to 2000 yards. About 100 units were manufactured by the E.W. Bliss Co.

CHARACTERISTICS

PHYSICAL

Length	204 inches
Diameter	17.7 inches
Weight	≅ 1800 pounds
Propulsion	Turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Preset
Warhead	Info not available
Exploder	War Nose Mk 5*
	Contact

PERFORMANCE

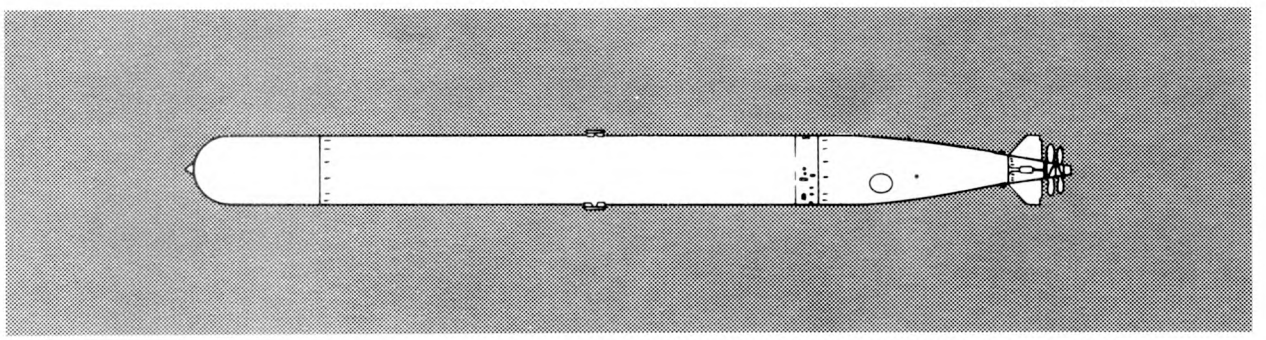
Speed	35 knots
Range	2000 yards

*War Nose Mk 1, Mk 2, and Mk 5 were used interchangeably.

Bliss-Leavitt Torpedo Mk 7

DEVELOPMENT DATE:
1911

APPROXIMATE IN-SERVICE DATES:
1912-1945



Torpedo Mk 7, a submarine/destroyer-launched antisurface ship torpedo, was a major step forward in the evolution of the modern torpedo. It featured the introduction of water into the combustion pot to cool the combustion gases and produce steam. Propulsive efficiency was increased which, in turn, resulted in an increase in the range. Developed by the Bliss-Leavitt Co., Brooklyn, N.Y., and the Naval Torpedo Station, Newport, R.I., Torpedo Mk 7 was issued to the Fleet in 1912 and remained in service through World War II. This torpedo was also in development/experimentation as an aircraft-launched weapon in the early 1920s.

CHARACTERISTICS

PHYSICAL

Length	204 inches
Diameter	17.7 inches
Weight	1628 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Flask Air Pressure	2000/2500 psi (depending on mod)
Homing	No
FC Settings	Mechanical
Warhead	Mk 7 Mod 5 326 pounds TNT or TPX
Exploder	Mk 3 Mod 1 Contact

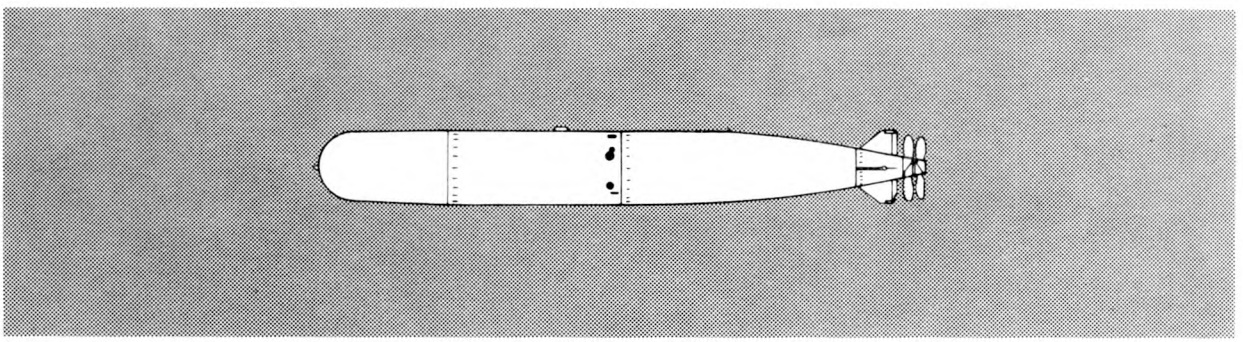
PERFORMANCE

Speed	35 knots
Range	3500/6000 yards (depending on mod)

Short Torpedo Mk7 (Type D)

DEVELOPMENT DATE:
1917

APPROXIMATE IN-SERVICE DATES:
NO RECORD OF SERVICE USE



The Type D Torpedo was a shorter version of the Mk 7 torpedo. Developed by Washington Navy Yard, Washington, D.C., in order to fit certain submarine torpedo tubes, the Mk 7 air flask was shortened and the weight of the warhead was reduced. The fuel and water tanks were relocated to obtain more air flask capacity on the Type D. The fuel tank was mounted in the aft air flask bulkhead while the water tanks were mounted in the afterbody. The overall weight of the warshot torpedo, as compared to the Mk 7, was 590 pounds lighter and 58 inches shorter. In addition, air, fuel and water capacities were approximately one-third of the capacities found in the Mk 7 torpedo. This torpedo was never produced in quantity.

CHARACTERISTICS

PHYSICAL

Length	144 inches
Diameter	17.7 inches
Weight	1036 pounds
Propulsion	Turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2250 psi
Homing	No
FC Settings	Mechanical
Warhead	Total weight - 281 pounds
Exploder	Mk 3 Contact

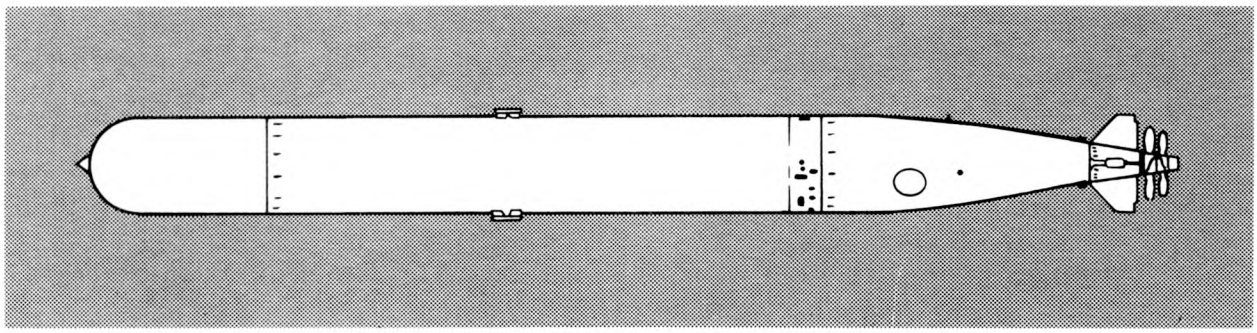
PERFORMANCE

Speed	35 knots
Range	= 2000 yards

Bliss-Leavitt Torpedo Mk 8

DEVELOPMENT DATE:
1911

APPROXIMATE IN-SERVICE DATES:
1911-1945



Developed during World War I, the Mk 8 was the U.S. Navy's first 21-inch by 21-foot torpedo. The Naval Torpedo Station at Newport, R.I., the Torpedo Station in Alexandria, Va., and the U.S.N. Gun Factory in Washington, D.C. were all involved in the production of this destroyer-launched, antisurface ship torpedo which was still in the inventory at the start of the second World War. Approximately 600 Mk 8 torpedoes were issued to Great Britain to use with 50 old-type U.S. destroyers turned over to England under the lend-lease act.

CHARACTERISTICS

PHYSICAL

Length	256.3 inches
Diameter	21 inches
Weight	2600 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Flask Air Pressure	2800 psi
Homing	No
FC Setting	Mechanical
Warhead	Mk 8 Mod 4
	466 pounds TNT
Exploder	Mk 3 Mod 2
	Contact

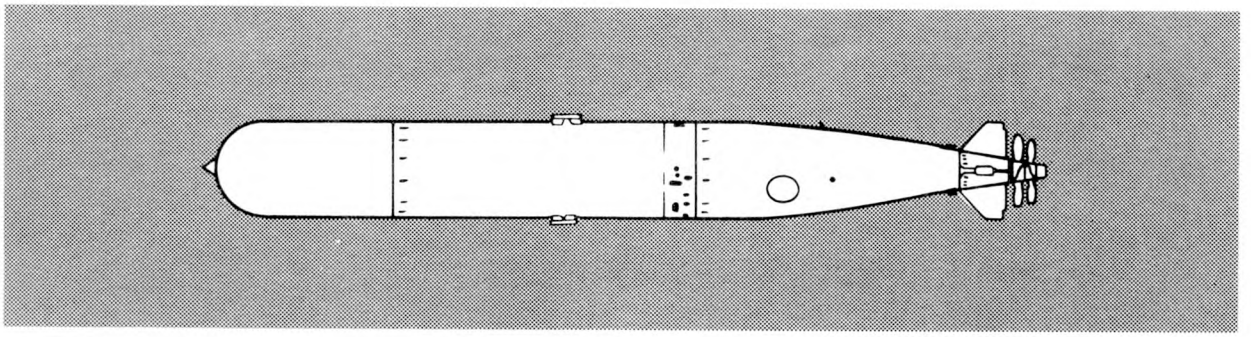
PERFORMANCE

Speed	36 knots
Range	16,000 yards

Bliss-Leavitt Torpedo Mk 9

DEVELOPMENT DATE:
1915

APPROXIMATE IN-SERVICE DATES:
1915-1945



Developed around 1915 by the Naval Torpedo Station, Newport, R.I., and the E.W. Bliss Co., Brooklyn, N.Y., Torpedo Mk 9 was designed for use by battleships. Prior to issue, however, use of torpedoes on battleships was discontinued and Mk 9 torpedoes were placed in reserve (storage). Modified for use in R- and S-class submarines, this antisurface ship torpedo was used in early World War II to supplement the initial supply of Torpedoes Mk 14. Torpedo production for the U.S. Navy was terminated by the E.W. Bliss Co. about 1920 after completion of the Mk 9 project.

CHARACTERISTICS

PHYSICAL

Length	197 inches
Diameter	21 inches
Weight	2015 pounds
Propulsion	Turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2000 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 9 210 pounds TNT
Exploder	Mk 3 Mod 2 Contact

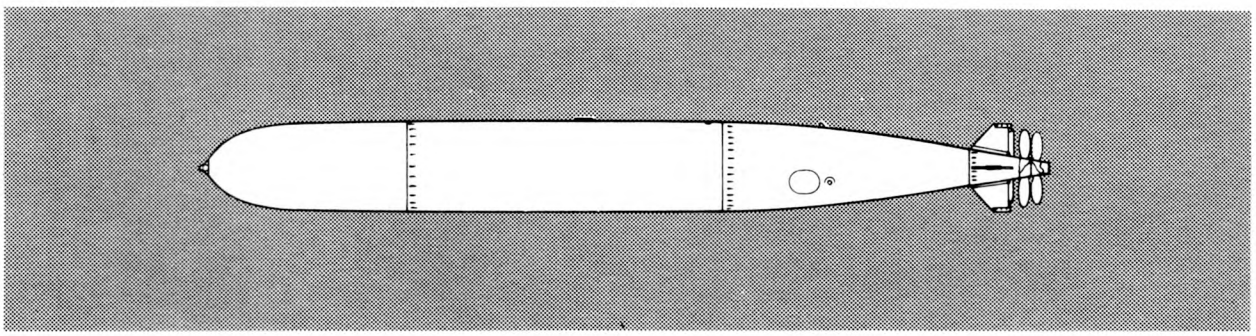
PERFORMANCE

Speed	27 knots
Range	7000 yards

Torpedo Mk10

DEVELOPMENT DATE:
1915

APPROXIMATE IN-SERVICE DATES:
1915-1945



Torpedo Mk 10 was developed by the E.W. Bliss Co. and the Naval Torpedo Station, Newport, R.I., and produced in 1915 by the Torpedo Station, to be used as a fast, short-range, antisurface ship torpedo. The Mk 10 featured the largest payload (warhead of ≅500 pounds) of any torpedo developed up to that time. Used in R- and S-class submarines after World War I, this torpedo saw service in the early years of the second World War.

CHARACTERISTICS

PHYSICAL

Length	195 inches
Diameter	21 inches
Weight	2215 pounds
Propulsion	Steam turbine, alcohol
Enabling	No
Guidance	Gyro, straight running
Flask Air Pressure	2500 psi
Homing	None
FC Settings	Mechanical
Warhead	Mk 10 Mod 3 497 pounds TNT
Exploder	Mk 3 Contact

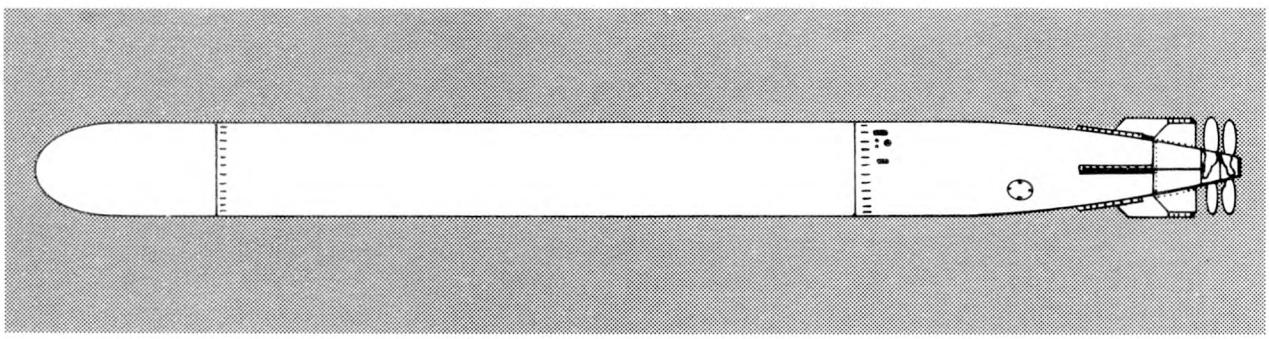
PERFORMANCE

Speed	36 knots
Range	3500 yards

Torpedo Mk 11

DEVELOPMENT DATE:
1926

APPROXIMATE IN-SERVICE DATES:
1926-1945



Developed by Washington Navy Yard, Washington, D.C., and the Naval Torpedo Station, Newport, R.I. the Mk 11 torpedo was a destroyer-launched, antisurface ship torpedo which had the first three-speed setting capability (selectable while tube loaded). The development was completed in 1926 and Torpedo Mk 11 became the first torpedo to be designed totally within the Navy (without industry collaboration). An objective was to attain a "universal" use torpedo (i.e., could be launched from any type of platform).

CHARACTERISTICS

PHYSICAL

Length	271 inches
Diameter	21 inches
Weight	3511 pounds
Propulsion	Turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2800 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 11 500 pounds TNT
Exploder	Mk 3 Mod 1 Contact

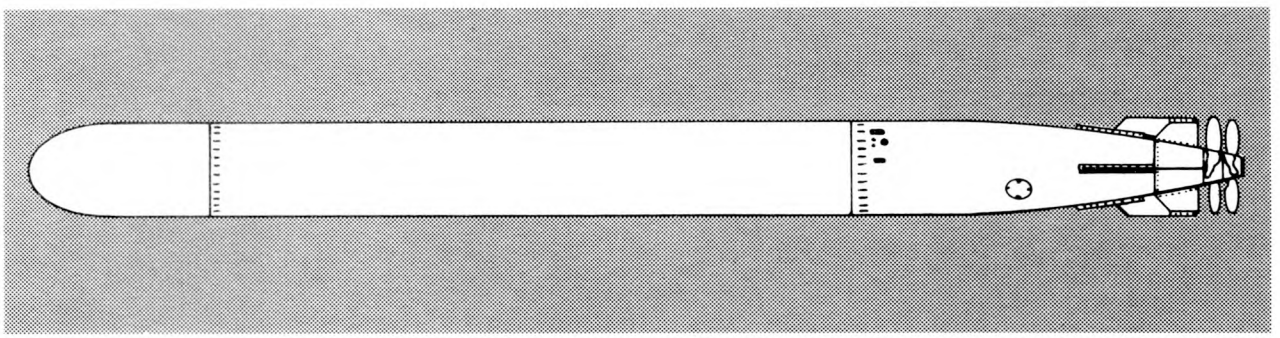
PERFORMANCE

Speed (knots)	
Low	27
Medium	34
High	46
Range (yards)	
Low	15,000
Medium	10,000
High	6000

Torpedo Mk12

DEVELOPMENT DATE:
1928

APPROXIMATE IN-SERVICE DATES:
1928-1945



Similar in design to the Mk 11 torpedo (but with detail refinements), Torpedo Mk 12 was a destroyer-launched, antisurface ship torpedo. This torpedo had a lower high-power setting than the Mk 11 (44 versus 46 knots) to improve reliability. The development of this torpedo by the Naval Torpedo Station, Newport, R.I., was completed in 1928. Two hundred units were manufactured by the Torpedo Station.

CHARACTERISTICS

PHYSICAL

Length	271 inches
Diameter	21 inches
Weight	3505 pounds
Propulsion	Turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2800 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 11 500 pounds TNT
Exploder	Mk 3 Mod 1 Contact

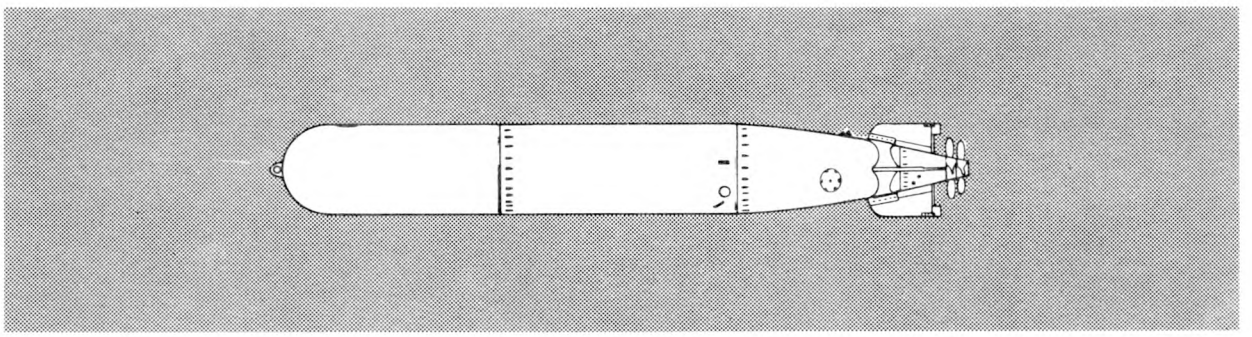
PERFORMANCE

Speed (knots)	
Low	27.5
Medium	35.5
High	44
Range (yards)	
Low	15,000
Medium	10,000
High	7000

Torpedo Mk13

DEVELOPMENT DATE:
1936

APPROXIMATE IN-SERVICE DATES:
1938-1950



Torpedo Mk 13 was the first torpedo designed specifically for aircraft launching. Developed by the Naval Torpedo Station, Newport, R.I., approximately 17,000 of these antisurface ship torpedoes were produced during World War II. Among the producers were the Naval Torpedo Station; Pontiac Motor Division, Pontiac, Mich.; the Amertorp Corp., Forest Park Ill., and St. Louis, Mo.; and the International Harvester Co. The Mk 13 torpedo saw service during the second World War and was eventually outmoded by ASW torpedoes.

CHARACTERISTICS

PHYSICAL

Length	161 inches
Diameter	22.5 inches
Weight	2216 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Flask Air Pressure	2800 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 13 600 pounds TPX
Exploder	Mk 8 Contact

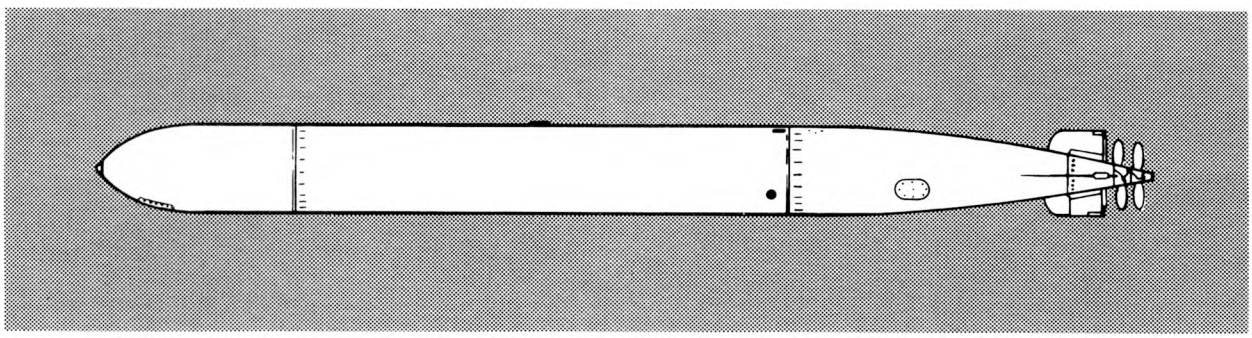
PERFORMANCE

Speed	33.5 knots
Range	6300 yards

Torpedo Mk14

DEVELOPMENT DATE:
1931

APPROXIMATE IN-SERVICE DATES:
1938



Torpedo Mk 14, developed as a replacement for the Mk 10 torpedo had a longer range than the Mk 10 and had a 100-pound heavier warhead charge. This torpedo was the primary submarine-launched, antisurface ship torpedo used in World War II until the introduction of the electric Torpedo Mk 18. Approximately 4,000,000 tons of Japanese shipping were sunk by the Mk 14 torpedo. Originally introduced for use as mechanically-set torpedo, the Mk 14 was modified for use with modern fire control systems (and designated Mod 5). This torpedo is still in service use. Torpedo Mk 14 was developed by the Naval Torpedo Station, Newport, R.I. and approximately 13,000 were produced during the second World War by the Naval Torpedo Stations in Newport; Alexandria, Va.; and Keyport, Wash.; and the Naval Ordnance Plant, Forest Park, Ill.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3209 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Homing	No
FC Settings	Electrical
Warhead	Mk 16 Mod 6 643 pounds HBX
Exploder	Mk 6 Mod 13 Contact

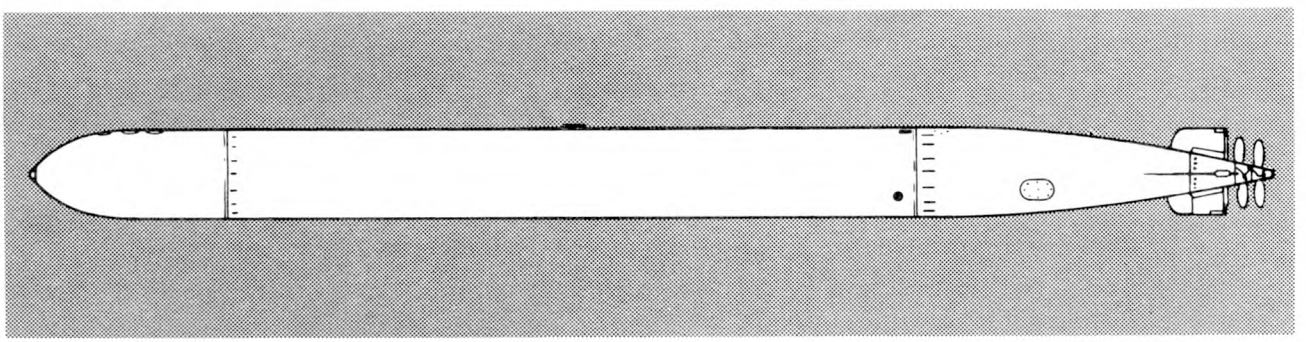
PERFORMANCE

Speed (knots)	
Low	31.1
High	46.3
Range (yards)	
Low	9000
High	4500

Torpedo Mk15

DEVELOPMENT DATE:
1935

APPROXIMATE IN-SERVICE DATES:
1938-1956



Developed and produced by the Naval Torpedo Station, Newport, R.I., Torpedo Mk 15 was designed as a replacement for the Mk 11 and Mk 12 torpedoes in surface ship application. It was 17 inches longer and 300 pounds heavier than its predecessors. The additional weight was due to increased payload. Approximately 9700 Mk 15 torpedoes were produced during the period 1940 through 1944. This torpedo was the last destroyer-launched, antisurface ship torpedo in wide service use. As part of the Fleet modernization program of the 1950's, it was phased out of service by the removal of the quintuple-mount torpedo tubes from destroyers. Torpedo Mk 15 was developed by the Naval Torpedo Station, Newport, R.I., and produced by the Torpedo Station and by the Naval Ordnance Plant, Forest Park, Ill.

CHARACTERISTICS

PHYSICAL

Length	288 inches
Diameter	21 inches
Weight	3841 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Homing	No
FC Settings	Mechanical
Warhead	Mk 17 Mod 3 825 pounds HBX
Exploder	Mk 6 Mod 13 Contact

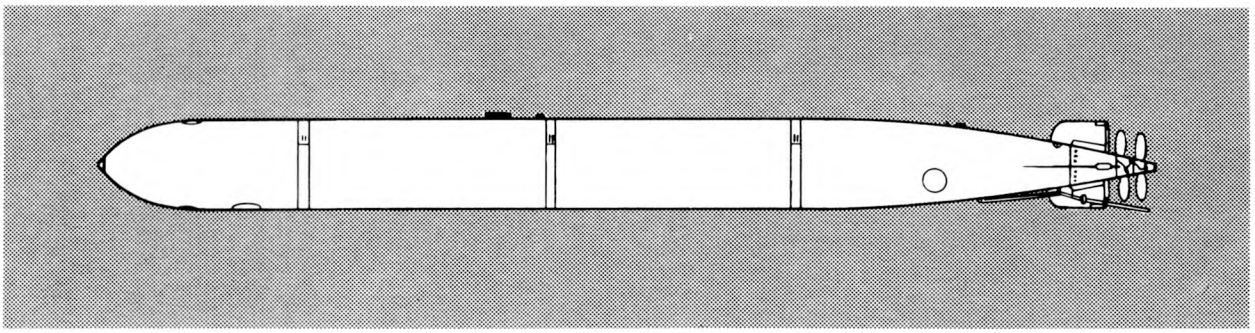
PERFORMANCE

Speed (knots)	
Low	26.5
Medium	33.5
High	45.0
Range (yards)	
Low	15,000
Medium	10,000
High	6,000

Torpedo Mk16

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
1944-1975



In 1943, the Naval Torpedo Station, Newport, R.I., and the Naval Research Laboratory, Washington, D.C., began development of a submarine-launched, antisurface ship torpedo designated Torpedo Mk 16. The decision to use "Navol" (concentrated hydrogen peroxide (H_2O_2O)) as an oxidant came as a result of research on chemical torpedoes which began in 1915. Torpedo Mk 16, which was also produced at the Torpedo Station in Newport, and at the Naval Ordnance Plant, Forest Park, Ill., had the same physical characteristics as the Mk 14 Mod 3 torpedo. As a result of World War II, production began before development was completed on this torpedo. None of the Mk 16 torpedoes were used in combat, although 60 units were completed prior to the end of the war. Production continued in post-World War II years, however, with over 1700 Torpedoes Mk 16 manufactured. The final version was Torpedo Mk 16 Mod 8 which was withdrawn from service use in 1975.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	4000 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	Yes
Homing	No
FC Settings	Electrical
Warhead	Mk 16 Mod 7 746 pounds HBX
Exploder	Mk 9 Mod 4 Contact/Influence

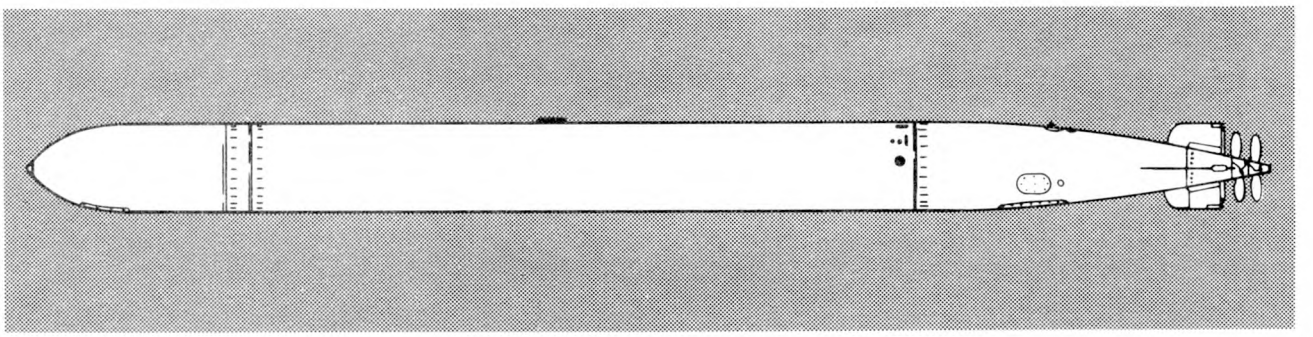
PERFORMANCE

Speed	46.2 knots
Range	11,000 yards

Torpedo Mk 17

DEVELOPMENT DATE
1940

APPROXIMATE IN-SERVICE DATES:
1944-1950



Development on Torpedo Mk 17 began in 1940 by the Naval Torpedo Station, Newport, R.I., and the Naval Research Laboratory, Washington, D.C. A long-range, high-speed torpedo, the Mk 17 was a destroyer-launched, antisurface ship weapon using "Navol" (concentrated hydrogen peroxide (H_2O_2O)) as an oxidant. Torpedo Mk 17 development, halted in 1941 due to pressure to produce Torpedoes Mk 13 and Mk 15 for the war effort, was resumed again in 1944. (Detailed knowledge of the Japanese type 93 "Long Lance," a 22,000-yard, 49-knot oxygen torpedo became available about this time.) As in the case of the Mk 16 torpedo, the Mk 17 went into production before development was completed. The producer was the Torpedo Station in Newport. Although there were 450 Mk 17 torpedoes completed before the end of the second World War, none were used in combat. Torpedo Mk 17 was discontinued around 1950 after seeing only limited use in post-war years. Main factors in the early demise of the Mk 17 were its contribution to destroyer topside weight, similarity to the Mk 16, and, also, the emerging role of destroyer as an antisubmarine warfare platform.

CHARACTERISTICS

PHYSICAL

Length	288 inches
Diameter	21 inches
Weight	4600 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Flask Air Pressure	2800 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 17 Mod 3 879.5 pounds HBX
Exploder	Mk 6 Mod 1 Contact

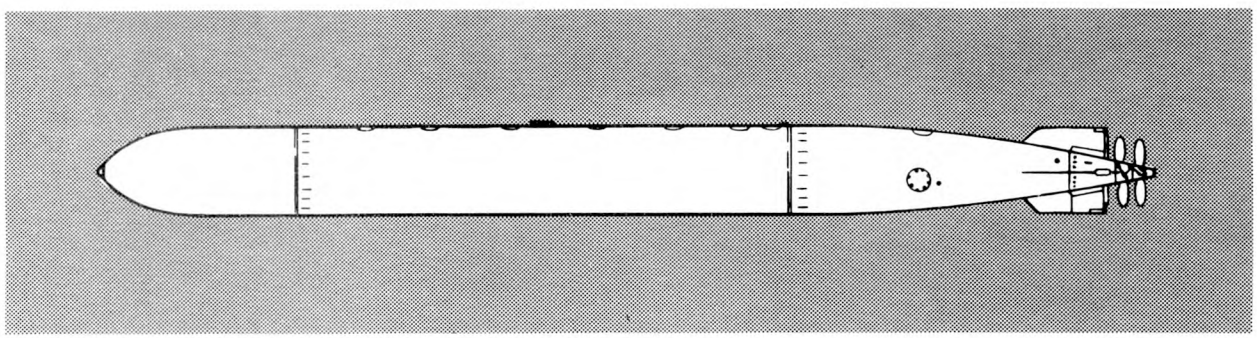
PERFORMANCE

Speed	46 knots
Range	18,000 yards

Torpedo Mk18

DEVELOPMENT DATE:
1942

APPROXIMATE IN-SERVICE DATES:
1943-1950



Torpedo Mk 18, a submarine-launched, antisurface ship weapon, was one of the most successful torpedoes of World War II. This torpedo, based on a captured G7e German torpedo, was widely used in the latter stages of the war. Torpedo Mk 18 was developed by the Westinghouse Electric Corp., Sharon, Pa., and the Electric Storage Battery Co., Philadelphia, Pa., and approximately 9000 were produced by Westinghouse and the Naval Ordnance Plant, Forest Park, Ill. In 1944, 30 percent of the torpedoes fired from submarines were Mk 18 torpedoes, while in 1945, it was 65 percent. The tactical advantage of Torpedo Mk 18 was the lack of a wake. About 1,000,000 tons of Japanese shipping were sunk by the Mk 18 torpedo.

CHARACTERISTICS

PHYSICAL

Length	245 inches
Diameter	21 inches
Weight	3154 pounds
Propulsion	Electric motor
Guidance	Gyro
Enabling	No
Homing	No
FC Settings	Mechanical
Warhead	Mk 18 Mod 3 575 pounds HBX
Exploder	Mk 8 Contact Mk 9 Contact/Influence

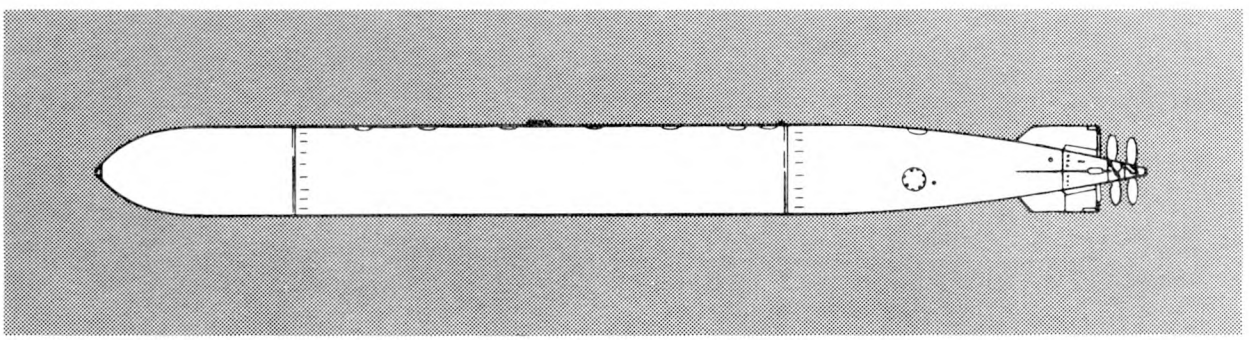
PERFORMANCE

Speed	29 knots
Range	4000 yards

Torpedo Mk19

DEVELOPMENT DATE:
1942

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 19 was a follow-on development of the Mk 18 torpedo, designed to incorporate all-electric controls in lieu of pneumatic controls. The Mk 19, an antisurface ship torpedo, which was developed by the Westinghouse Electric Corp., Sharon, Pa., was designed to be submarine launched. The propulsion power was supplied by a direct current, series-wound motor which received its energy from a secondary storage battery. The gyroscope and depth control were electrically controlled and operated; the rudders were solenoid operated. Ten prototypes were built, but further development was cancelled in favor of Torpedo Mk 26.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3240 pounds
Propulsion	Electric, secondary battery
Enabling	Yes
Guidance	Gyro
Homing	None
FC Settings	Mechanical
Warhead	Mk 20 800 pounds Torpex
Exploder	Mk 7 Contact/Influence

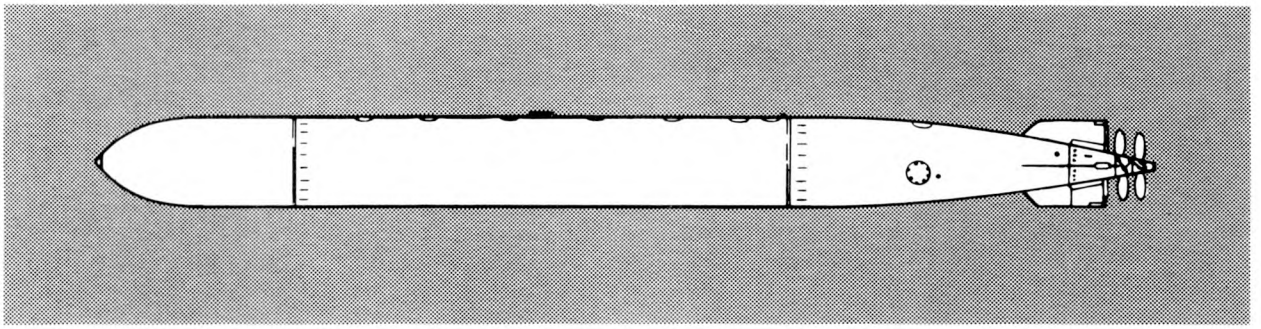
PERFORMANCE

Speed	29 knots
Range	4000 yards

Torpedo Mk20

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 20 was actually the 1943 designation for the continuation of the development of a submarine-launched, antisurface ship torpedo originally designated Mk 2 (in 1941). The torpedo was developed by the Naval Torpedo Station, Newport, R.I.; the Electric Storage Battery Co., Philadelphia, Pa.; and the General Electric Co., Pittsfield, Mass. This was the second attempt to develop a torpedo of this type. Earlier efforts (Mk 1) in post-World War I years (1919-1931) were terminated due to unsatisfactory speed/range performance. Torpedo Mk 20 never progressed beyond the development stage due to the success of the Mk 18 torpedo. However, 20 units were produced by the General Electric Co., Bridgeport, Conn., for testing.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	$\cong$ 3100 pounds
Propulsion	Electric motor
Guidance	Gyro
Enabling	No
Homing	No
FC Settings	Mechanical
Warhead	Mk 20 500 pounds TNT
Exploder	None assigned

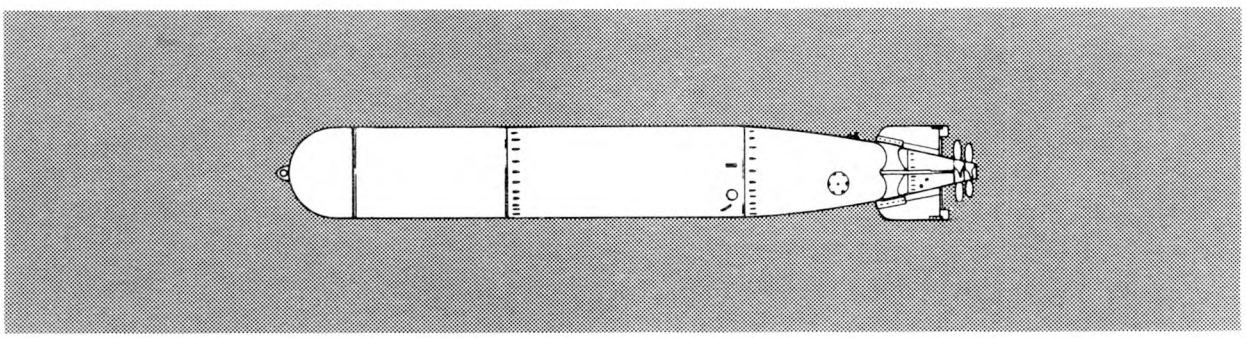
PERFORMANCE

Speed	33 knots
Range	3500 yards

Torpedo Mk21 Mod 0

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 21 Mod 0, an antisurface ship, aircraft-launched, passive acoustic homing torpedo was developed by the Westinghouse Electric Corp., Sharon, Pa. During the same time period, the Harvard Underwater Sound Laboratory, Harvard University; and the Bell Telephone Laboratories, Murray Hills, N.J., were adapting Torpedo Mk 13 for acoustic control. The Mk 21 Mod 0 torpedo successfully passed launching tests late in 1943. Because of the increasing difficulties encountered by the developer, the Torpedo Mk 21 Mod 0 project was abandoned after only a few development models had been built.

CHARACTERISTICS

PHYSICAL

Length	161 inches
Diameter	22.5 inches
Weight	≅ 2300 pounds
Propulsion	Electric
Enabling	No
Guidance	Gyro
Homing	Passive acoustic
FC Settings	Preset
Warhead	Mk, Mod not available ≅ 400 pounds HBX
Exploder	Mk 8 Contact

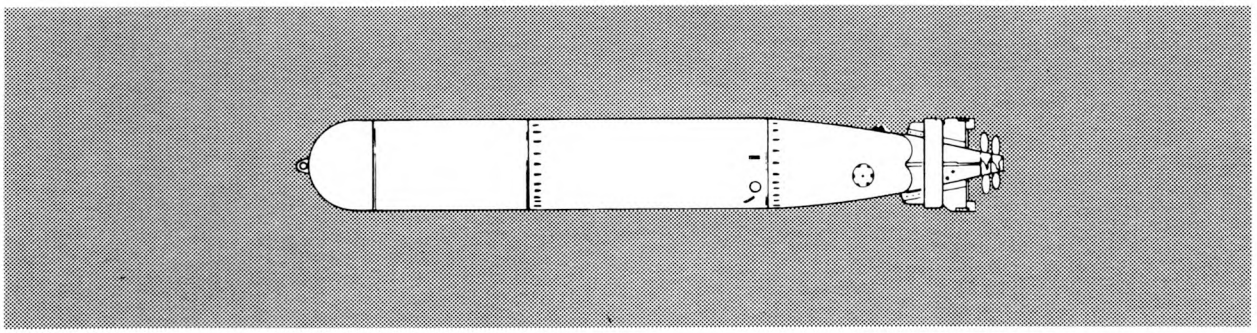
PERFORMANCE

Speed	25 knots
Range	Not specified

Torpedo Mk21 Mod2

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 21 Mod 2 was a passive homing version of the Mk 13 torpedo intended for use as a payload for the Petrel guided missile. An aircraft-launched, antisurface ship weapon, it was developed as a joint effort by the Bell Telephone Laboratories, Murray Hill, N.J.; the Harvard Underwater Sound Laboratory, Harvard University; and later, the Ordnance Research Laboratory, Pennsylvania State University. The Naval Ordnance Plant, Forest Park, Ill., produced a limited quantity (312) during 1946 through 1955. Development was discontinued and this torpedo was not used in service to any appreciable degree.

CHARACTERISTICS

PHYSICAL

Length	161 inches
Diameter	22.5 inches
Weight	2130 pounds
Propulsion	Steam turbine
Enabling	None
Guidance	Gyro
Flask Air Pressure	2800 psi
Homing	Passive acoustic
FC Setting	Mechanical
Warhead	Mk 21
	350 pounds HBX-3
Exploder	Mk 8
	Contact

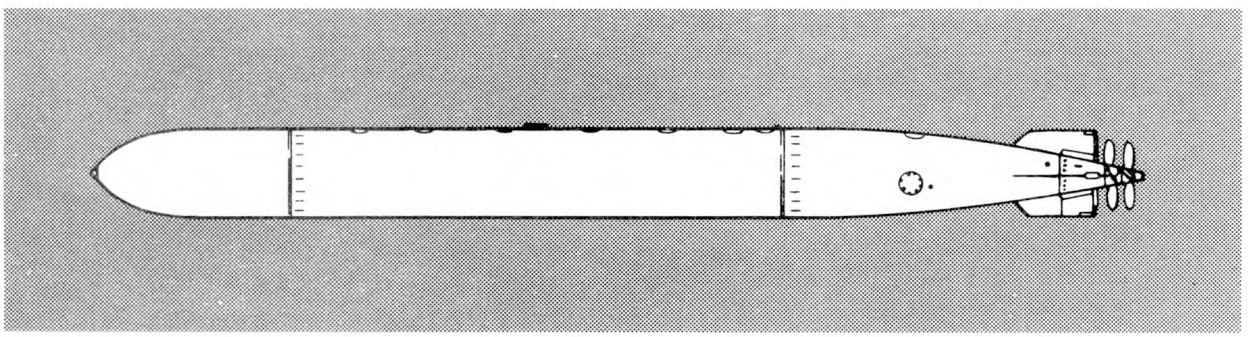
PERFORMANCE

Speed	33.5 knots
Range	6000 yards

Torpedo Mk22

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Developed by the Bell Telephone Laboratories, Murray Hill, N.J.; and Westinghouse Electric Corp., Sharon, Pa., Torpedo Mk 22 was the World War II development of an antisurface ship, submarine-launched torpedo. It had active acoustic terminal homing in azimuth only, probably in an attempt to reduce boundary (surface/bottom) capture problems. Further development on this torpedo was discontinued after the BuOrd evaluation stage, which coincided with the end of the second World War. The decision to continue with the development of Torpedo Mk 35 during the post-war years was the probable cause for the discontinuation of Mk 22 work.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3060 pounds
Propulsion	Electric
Enabling	Yes
Guidance	Gyro
Homing	Active acoustic
FC Settings	Mechanical
Warhead	Info not available 500 pounds HBX
Exploder	Info not available

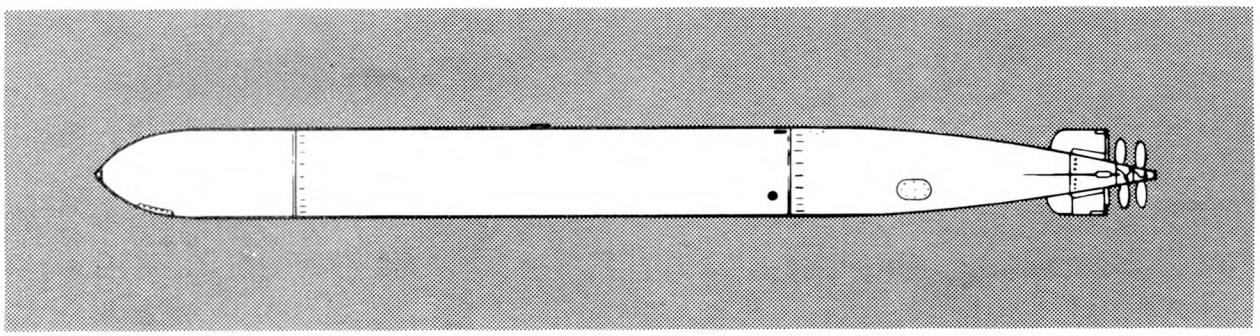
PERFORMANCE

Speed	29 knots
Range	4000 yards

Torpedo Mk23

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
1943-1946



Torpedo Mk 23 was developed to satisfy what appeared to be a valid tactical requirement of World War II: the high-speed feature of the Mk 14 torpedo. In the early stages of the war, the low-speed feature (31 knots - 9000 yards) of the Mk 14 was rarely used. Due to the changing requirements of the war, however, most of the 9600 Mk 23 torpedoes saw little service. In the latter stages of the second World War, fewer targets and better/smarter escorts/escort tactics necessitated firing from longer ranges. The Mk 14 torpedo, with its low power and longer range, became the preferred weapon. Much of the Mk 23 inventory was scrapped or converted to Torpedoes Mk 14 while other units were cannibalized for spare parts. This submarine-launched, antisurface ship torpedo was developed by the Naval Torpedo Station, Newport, R.I., and produced by the Naval Torpedo Stations at Newport; Alexandria, Va.; and Keyport, Wash.; and by the Naval Ordnance Plant, St. Louis, Mo.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3259 pounds
Propulsion	Turbine
Guidance	Gyro
Enabling	No
Homing	No
FC Settings	Mechanical
Warhead	Mk 16 Mod 6 643 pounds HBX
Exploder	Mk 6 Mod 13 Contact

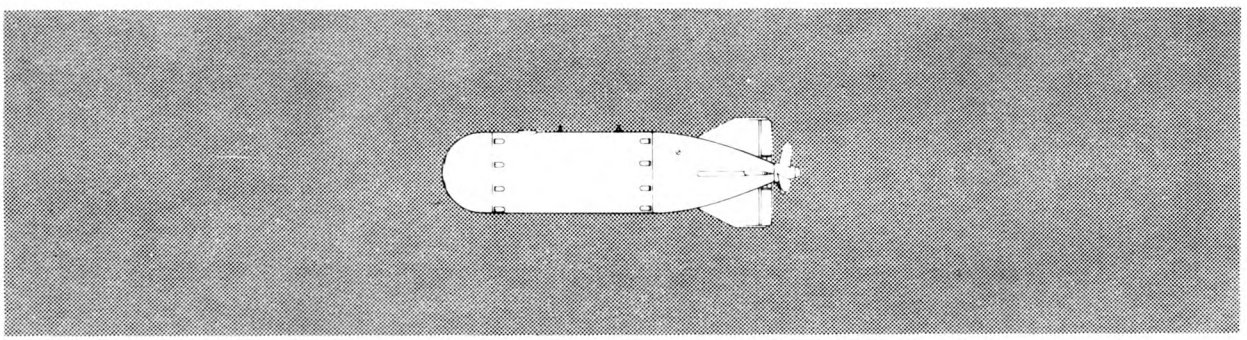
PERFORMANCE

Speed	46.3 knots
Range	4500 yards

Torpedo Mine Mk24

DEVELOPMENT DATE:
1942

APPROXIMATE IN-SERVICE DATES:
1942-1948



Called a mine for security reasons, the Mk 24 was developed as an outgrowth of work on an underwater listening device sponsored by the Naval Defense Research Committee during World War II. This torpedo, with a small warhead, was a crippling weapon designed for "mission kill" vice "platform kill." Approximately 4000 of these aircraft-launched, passive acoustic, antisubmarine torpedoes were produced and in service during World War II and subsequent years until replaced by Torpedo Mk 34. Mine Mk 24 was developed by a group of activities including Western Electric Co., Kearney, N.J.; Bell Telephone Laboratories, Murray Hill, N.J.; Harvard University Underwater Sound Laboratory, Cambridge, Mass.; and General Electric Co, Schenectady, N.Y. The Western Electric Co., Kearney, N.J., and General Electric Co. in Erie and Philadelphia, Pa. were the producers.

CHARACTERISTICS

PHYSICAL

Length	84 inches
Diameter	19 inches
Weight	680 pounds
Propulsion	Electric, secondary battery
Enabling	No
Guidance	Preset circle search
Homing	Passive acoustic
Warhead	Mine Mk 24 92 pounds HBX-1
Exploder	Mk 142 fuze Contact

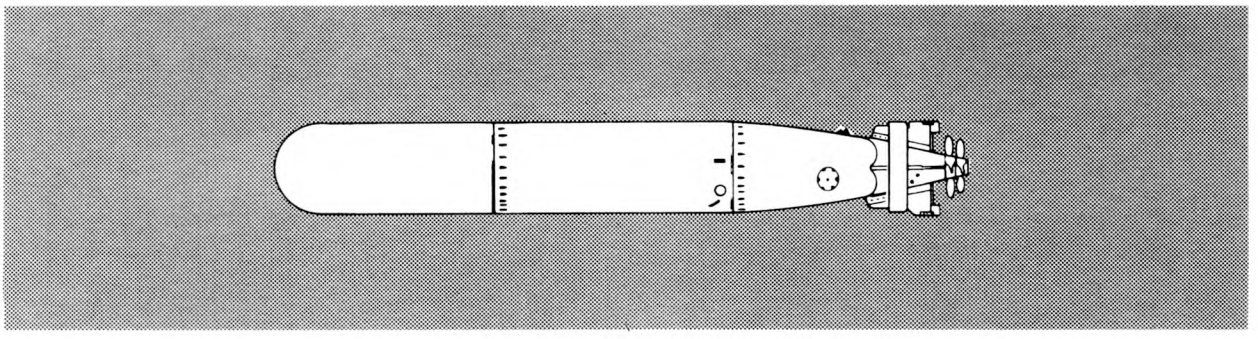
PERFORMANCE

Speed	12 knots
Range (search duration)	10 minutes = 4000 yards

Torpedo Mk25

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Sponsored by the National Defense Research Committee, Torpedo Mk 25 was developed by Columbia University, Division of War Research, as a replacement for Torpedo Mk 13. The new torpedo was an aircraft-launched, antisurface ship weapon designed for higher speed, greater strength and more ease of manufacture than the Mk 13 torpedo. Torpedo Mk 25 had thermal propulsion, was turbine driven and obtained a speed of 40 knots and a range of 2500 yards. Twenty-five units were produced by the Naval Ordnance Plant, Forest Park, Ill., during 1946 for test and evaluation. This torpedo was never mass-produced, however, due to the large inventory of Mk 13 torpedoes left at the end of World War II, and the changing role of Naval aircraft from a torpedo strike warfare platform to an antisubmarine warfare platform.

CHARACTERISTICS

PHYSICAL

Length	161 inches
Diameter	225 inches
Weight	2306 pounds
Propulsion	Alcohol turbine
Enabling	No
Guidance	Gyro
Flask Air Pressure	2800 psi
Homing	No
FC Settings	Mechanical
Warhead	Mk 25
	725 pounds
Exploder	Info not available

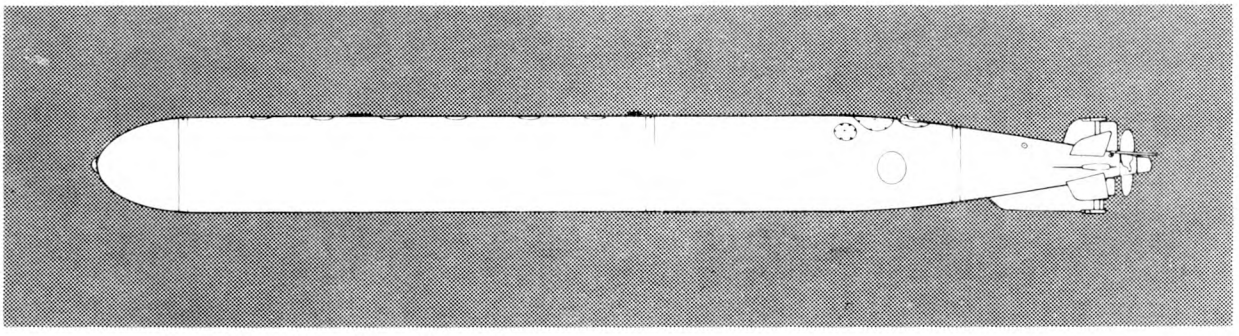
PERFORMANCE

Speed	40 knots
Range	2500 yards

Torpedo Mk26

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 26, an improved version of the Mk 28, was developed by the Westinghouse Electric Corp. as an antisurface ship, submarine-fired weapon. This torpedo introduced a primary (seawater) battery developed by Bell Telephone which provided high performance. The Mk 26 torpedo was also the first torpedo to use an explosive impulse start gyro and electric "on-off" control for steering and depth control. Approximately 25 developmental models were built by Westinghouse, but production was deferred in favor of the Mk 16 torpedo.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3200 pounds
Propulsion	Electric, seawater battery
Enabling	Yes
Guidance	Gyro
Homing	No
FC Settings	Electrical
Warhead	Mk 26 900-1000 pounds
Exploder	Info not available

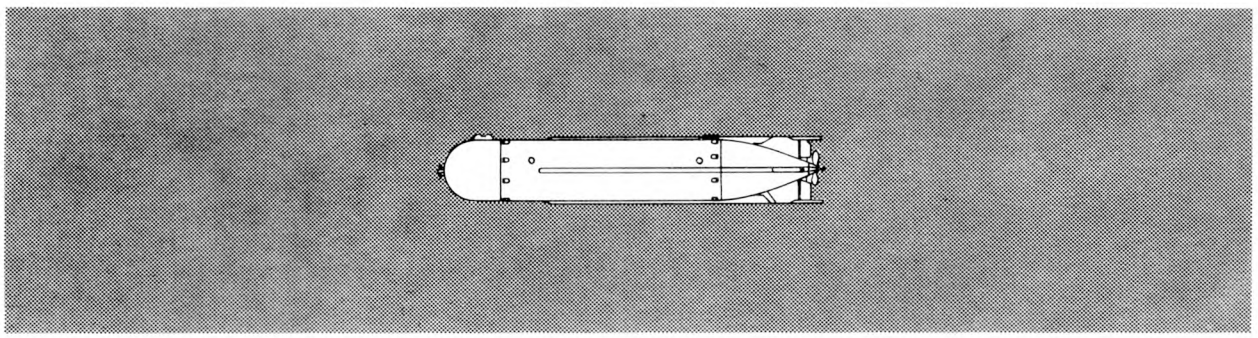
PERFORMANCE

Speed	40 knots
Range	6000 yards

Torpedo Mk27 Mod 0

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
1943-1946



Torpedo Mk 27 Mod 0, developed by Bell Telephone Laboratories, was an acoustically-controlled, submarine-launched, anti-escort ship weapon. Used during the second World War, the torpedo had a single propeller driven by an electric motor. This torpedo was essentially a Mine Mk 24 modified for submarine launching in a 21-inch submerged torpedo tube by the addition of wood guides on the outer cylinder shell. Approximately 1000 units were produced by the Western Electric Corp., Kearney, N.J.

CHARACTERISTICS

PHYSICAL

Length	90 inches
Diameter	19 inches (with 21-inch guide rails)
Weight	720 pounds
Propulsion	Electric, secondary battery
Guidance	Gyro
Enabling	Yes
Homing	Passive acoustic
Warhead	Mk 27 Mod 0 95 pounds HBX-1
Exploder	Mk 11 Mod 2 Contact

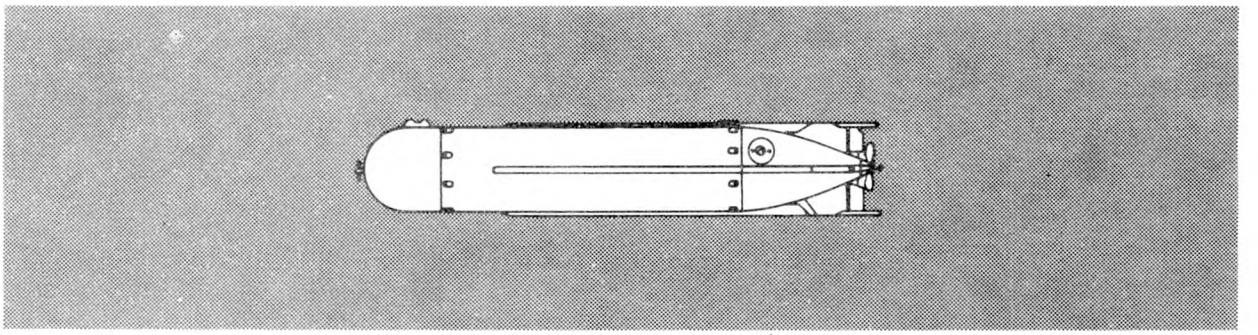
PERFORMANCE

Speed	12 knots
Range (search duration)	12 minutes $\cong$ 5000 yards

Torpedo Mk27 Mod4

DEVELOPMENT DATE:
1946

APPROXIMATE IN-SERVICE DATES:
1946-1960



Developed by the Ordnance Research Laboratory Pennsylvania State University, Torpedo Mk 27 Mod 4 was an improved version of the Mk 27 Mod 0. This torpedo was an anti-escort torpedo, fully compatible with electrical setting fire control systems through the incorporation of the standard 65-pin umbilical cable. Approximately 3000 of these torpedoes were produced by the American Kitchens Div. of the AVCO Corp., Connersville, Ind.; and the Naval Ordnance Plant, Forest Park, Ill., from 1946 through 1954. In service in submarines for about ten years, Torpedo Mk 27 Mod 4 was withdrawn from service use in 1960 with the introduction of Torpedo Mk 37.

CHARACTERISTICS

PHYSICAL

Length	125.75 inches
Diameter	19 inches (21-inch guide rails)
Weight	1175 pounds
Propulsion	Electric
Guidance	Gyro
Enabling	Yes
Homing	Yes
FC Setting	Electrical
Warhead	Mk 27 Mod 2 128 pounds HBX
Exploder	Mk 11 Mod 2 Contact

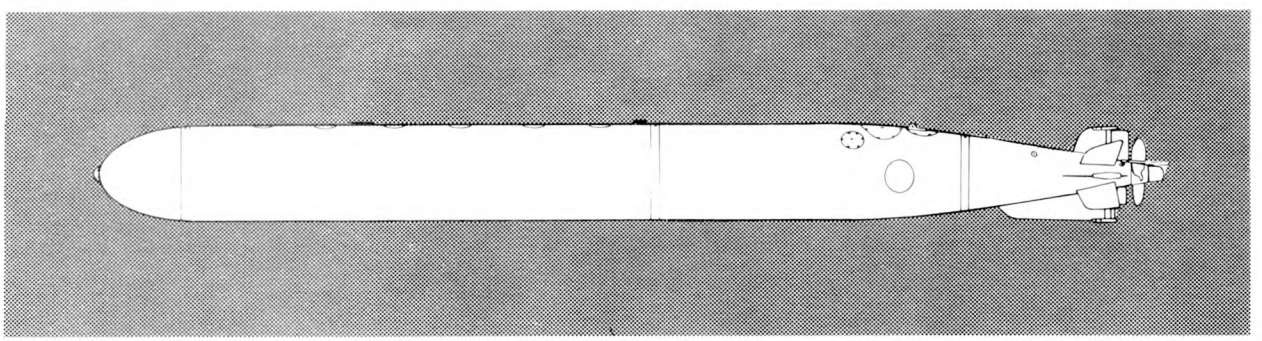
PERFORMANCE

Speed	15.9 knots
Range	12 minutes/6200 yards

Torpedo Mk28

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
1944-1960



Developed and produced late in World War II by the Westinghouse Electric Corp., Sharon, Pa., Torpedo Mk 28 was an antisurface ship, submarine-launched, acoustic homing torpedo with a medium explosive charge. The torpedo also incorporated all-electric controls. Approximately 1750 torpedoes were produced during the period from 1944 to 1952 but in-service use ceased after the introduction of Torpedo Mk 37.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	2800 pounds
Propulsion	Electric
Guidance	Gyro
Enabling	500-2500 yards
Homing	Passive
FC Settings	Mechanical
Warhead	Mk 28 Mod 2 585 pounds HBX
Exploder	Mk 14 Mod 2 Contact

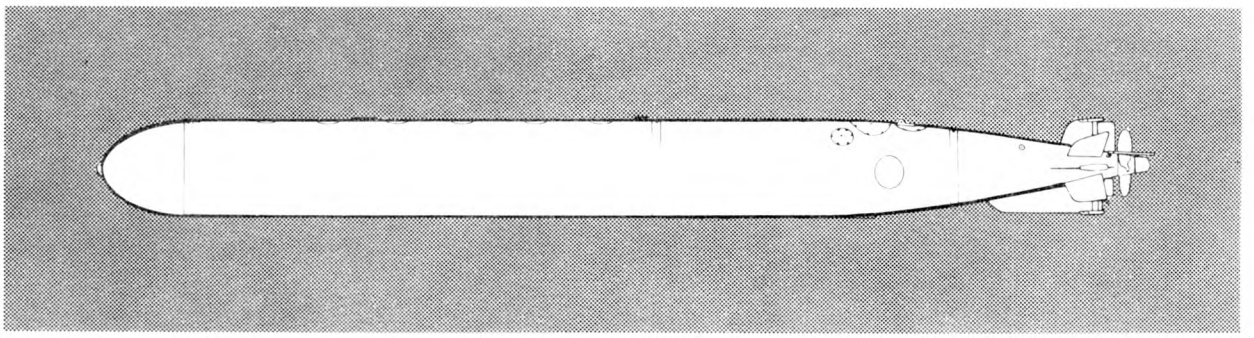
PERFORMANCE

Speed	19.6 knots
Range	4000 yards/6 minutes

Torpedo Mk29

DEVELOPMENT DATE:
1945

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 29 Mod 0 was an antisurface, submarine-launched, passive acoustic torpedo. This torpedo, developed by the Westinghouse Electric Corp., Sharon, Pa., used the same acoustic system as Torpedo Mk 28. Torpedo Mk 29 Mod 0 differed significantly from the Mk 28 in other ways, however. The newer torpedo was faster, operated at various depths, had an external depth setter, and ran as either a straight or a homing torpedo. Torpedo Mk 29 Mod 1, developed during the same time period, had two speeds, a remote-setting variable enabler and an anticircular run device. In the Mod 1, the electric motor on the impulse start gyro was replaced by a cartridge-start impeller motor to obtain a longer gyro controlling time. In April 1945, the Mk 29 program was discontinued after BuOrd evaluation, due to the fiscal constraints of the peacetime economy and planned developments.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	3200 pounds
Propulsion	Electric
Enabling	Yes
Guidance	Gyro
Homing	Passive acoustic
FC Settings	Mechanical
Warhead	Mk 28 Mod 2 550 pounds HBX
Exploder	Mk 14 Mod 2 Contact

PERFORMANCE

Speed (knots)	
Low	21
High	28
Range (yards)	
Low	12,000
High	4000

Torpedo Mk30

DEVELOPMENT DATE:
1944

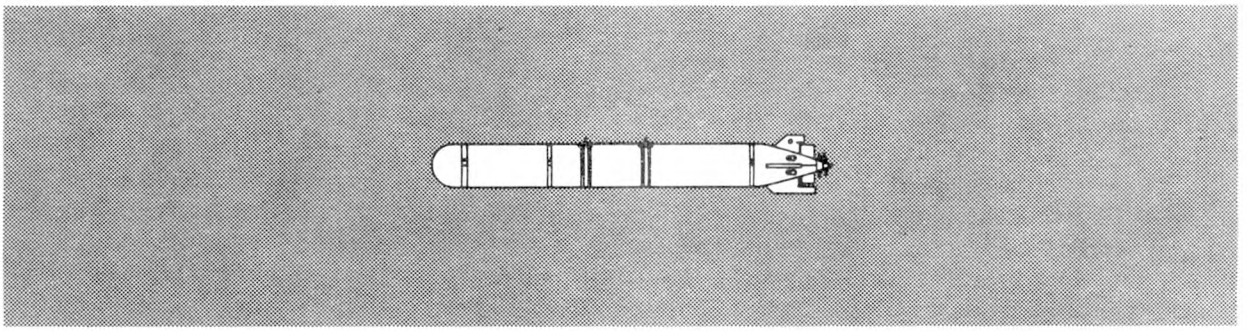
APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE

Optical wake sensing devices developed in Australia were the basis of Torpedo Mk 30 development by the Naval Ordnance Laboratory, Washington, D.C. The Mk 30 was a destroyer/submarine-launched, antisurface ship, homing torpedo that used the wake of a target ship to operate the steering mechanism. Torpedoes Mk 18 and Mk 14 were used as test vehicles for the detector heads and control units of this wake following system. The test program for this torpedo was transferred from the Naval Mine Warfare Test Station in Solomon, Md., to the Ordnance Research Laboratory at Pennsylvania State University in 1946. Subsequently, the program was abandoned as a complete torpedo development. It was, however, continued as a study of a system for homing control.

Torpedo Mine Mk30

DEVELOPMENT DATE:
1942

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Mine Mk 30, an aircraft-launched, antisubmarine torpedo, was developed by the Brush Development Co., Cleveland, Ohio, during 1942 and early 1943. It was designed in parallel with and as a backup for Mine Mk 24 because, at that time, there was apprehension about the Mine Mk 24 acoustic steering. Mine Mk 30 was unique because of its size; it was 10 inches in diameter, 98 inches long, and weighed 265 pounds. (Fifty pounds of the total weight was the explosive charge.) Three prototype Mines Mk 30 were manufactured and tested in January of 1943 and satisfactory performance was indicated. No production of Mine Mk 30 was initiated, however, because of the successful acoustic steering of an aircraft-launched Mine Mk 24 in late 1942.

CHARACTERISTICS

PHYSICAL

Length	96 inches
Diameter	10 inches
Weight	265 pounds
Propulsion	Electric
Enabling	No
Guidance	Gyro
Homing	Passive acoustic
FC Settings	Mechanical
Warhead	Mk 30
	50 pounds
Exploder	Info not available

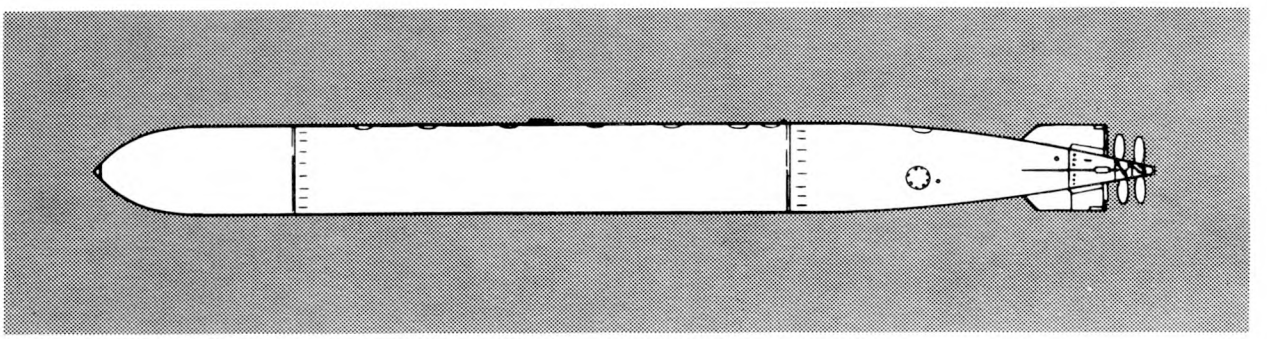
PERFORMANCE

Speed	12 knots
Range	3000 yards

Torpedo Mk31

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 31 Mod 1, an acoustically-steered modification of the Mk 18 electric torpedo, was conceived as a readily producible interim weapon to be used in the Pacific until an entirely new high-speed acoustic torpedo could be developed. The Mk 31, developed by the Harvard Underwater Sound Laboratory, and the Ordnance Research Laboratory, was a destroyer-launched, antisurface ship torpedo. Although some units of the Mk 31 torpedo were produced by the Naval Torpedo Station, Newport, R.I., further development of the torpedo was stopped after BuOrd evaluation due to the status of other development programs (Torpedoes Mk 16 and Mk 35).

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	2800 pounds
Propulsion	Electric
Enabling	Yes
Guidance	Gyro
Homing	Passive acoustic
FC Settings	Mechanical
Warhead	Mk 31
	500 pounds HBX
Exploder	Info not available

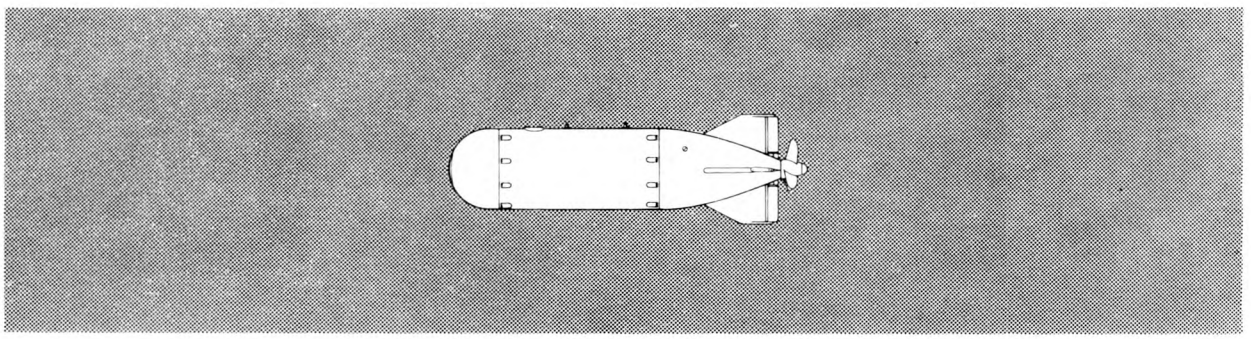
PERFORMANCE

Speed	29 knots
Range	4000 yards

Torpedo Mk32 Mod2

DEVELOPMENT DATE:
1950

APPROXIMATE IN-SERVICE DATES:
1950-1955



Torpedo Mk 32 Mod 2 was a surface ship-launched, antisubmarine torpedo featuring active acoustic homing. An end product of World War II acoustic homing system development, it was the first active acoustic torpedo. Developed by a combined effort between the General Electric Co., Schenectady, N.Y., and the Ordnance Reserach Laboratory, Pennsylvania State University, for aircraft launching, this torpedo saw limited use in destroyers with the Mk 2 over-the-side launchers for a number of years. A few (10) torpedoes of this type were produced by Leeds and Northrup, Philadelphia, Pa., during the second World War and approximately 3300 in post-war years by the Philco Corp., Philadelphia, and the Naval Ordnance Plant, Forest Park, Ill. Torpedo Mk 32 was withdrawn from service use with the introduction of the Mk 43 torpedo.

CHARACTERISTICS

PHYSICAL

Length	83 inches
Diameter	19 inches (25.4-inch fins)
Weight	700 pounds
Propulsion	Electric
Guidance	Helix search
Enabling	No
Homing	Active
FC Settings	Mechanical (preset)
Warhead	Mk 32 Mod 1 107 pounds HBX
Exploder	Mk 19 Mods 4 & 11 Contact

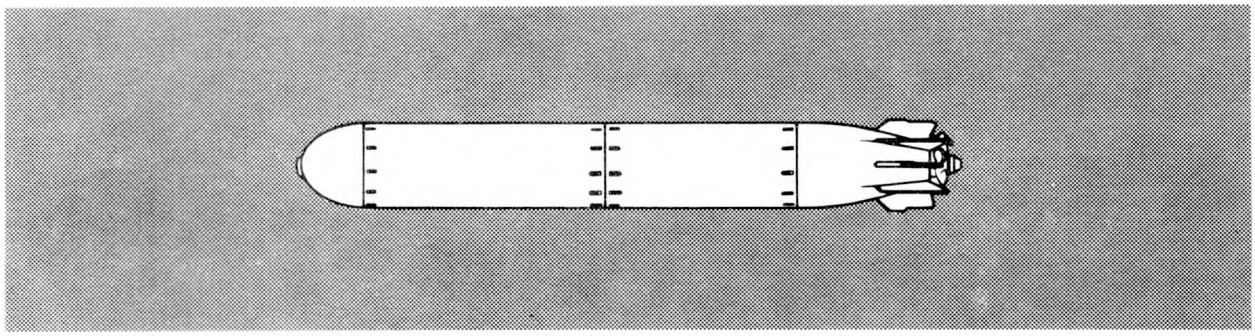
PERFORMANCE

Speed	12 knots
Range	24 minutes/9600 yards

Torpedo Mk33 Mod 0

DEVELOPMENT DATE:
1943

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 33 was a two-speed, passive acoustic homing, antisurface ship/antisubmarine torpedo designed to be launched from a standard submarine torpedo tube or aircraft. Developed by the Bureau of Ordnance, the General Electric Co., and the Exide Co., this torpedo had a hydraulic steering system and had the first cast aluminum shell. Only 30 models of the Mk 33 torpedo were constructed and tested between 1943 and 1946. Production was discontinued when World War II ended but Torpedo Mk 33 features were incorporated into the Mk 35 torpedo.

CHARACTERISTICS

PHYSICAL

Length	156 inches
Diameter	21 inches
Weight	1795 pounds
Propulsion	Electric
Enabling	Yes
Guidance	Gyro
Homing	Passive acoustic
FC Settings	Electrical
Warhead	Mk, Mod not available 550 pounds HBX
Exploder	Info not available

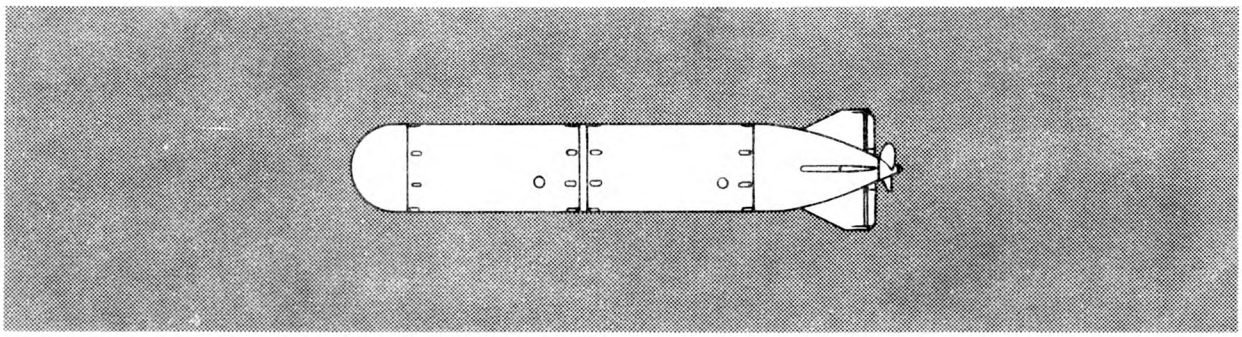
PERFORMANCE

Speed (knots)	
Low	12.5
High	18.5
Range (yards)	
Low	19,000
High	5,000

Torpedo Mk34 Mod 1 (Mine Mk 44)

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
1948-1958



Torpedo Mk 34 Mod 1 (initially designated Mine Mk 44), an improved version of Mine Mk 24, used magnetrostrictive hydrophones in lieu of crystal hydrophones. It also used two propulsion batteries in a parallel/series switching arrangement which provided for longer search time/range and a shift to higher speed during attack after acquisition. Developed by the U.S. Mine Warfare Test Station, Solomons, Md., approximately 4050 were produced during the period from 1948 through 1954. The main producers of this torpedo were the American Machine and Foundry Co., Buffalo, N.Y.; the Naval Ordnance Plant, Forest Park, Ill.; and the Naval Mine Depot, Yorktown, Va. In-service in ASW aircraft for many years, this torpedo was withdrawn from Fleet use with the introduction of Torpedo Mk 43.

CHARACTERISTICS

PHYSICAL

Length	125 inches
Diameter	19 inches (26.4 inches across fins)
Weight	1150 pounds
Propulsion	Electric
Guidance	Random search circles
Enabling	No
Homing	Passive
FC Setting	No
Warhead	Mk 34 Mod 1 116 pounds HBX
Exploder	Mk 19 Mod 7 Contact

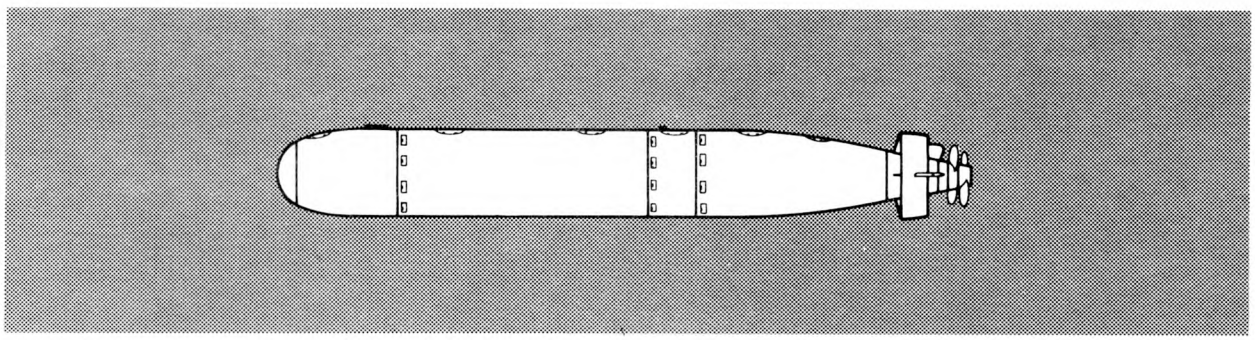
PERFORMANCE

Speed	
Search	11 knots
Attack	17 knots
Range	30 minutes/12,000 yards at 11 knots 6-8 minutes/3600 yards at 17 knots

Torpedo Mk35

DEVELOPMENT DATE:
1944

APPROXIMATE IN-SERVICE DATES:
1949-1960



Developed in 1944 by the General Electric Co., Torpedo Mk 35 was an outgrowth of work done on Mine Mk 24, and Torpedoes Mk 32 and Mk 33. This torpedo, intended as a "universal" torpedo (i.e., could be launched from any type of platform), was a surface ship-launched, antisurface ship weapon featuring deep diving and long range homing. Approximately 400 Mk 35 torpedoes were manufactured by G.E. Co., Aeronautical and Ordnance Systems Div., Pittsfield, Mass., during the period from 1949 through 1952. After having seen only limited service, Torpedo Mk 35 was withdrawn from Fleet use around 1960 as a result of the introduction of Torpedo Mk 37.

CHARACTERISTICS

PHYSICAL

Length	162 inches
Diameter	21 inches
Weight	1770 pounds
Propulsion	Electric, primary seawater battery
Enabling	Yes
Guidance	Gyro, helix search
Homing	Active, passive acoustic; spiral search pattern
FC Settings	Electrical
Warhead	Mk 35 Mods 2 or 3 270 pounds HBX
Exploder	Mk 19 Mod 3 Contact

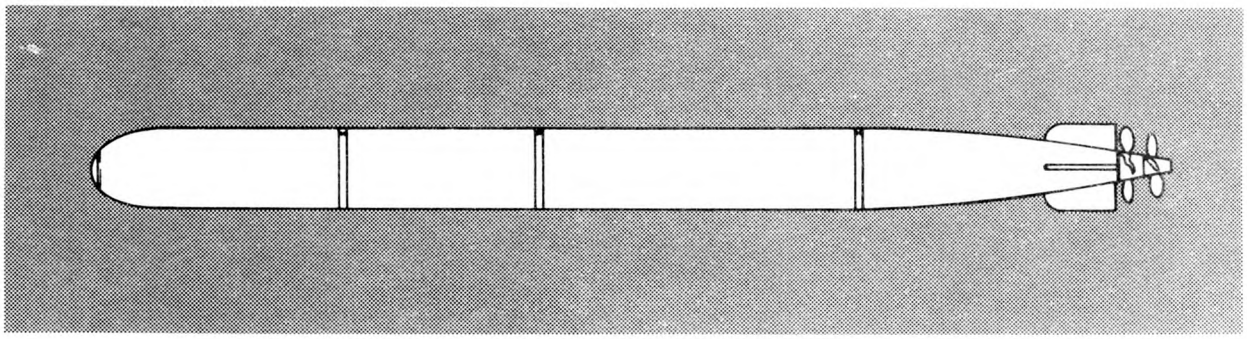
PERFORMANCE

Speed	27 knots
Range	15,000 yards

Torpedo Mk36 Mod 0

DEVELOPMENT DATE:
1946

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



The ultimate objective of the Torpedo Mk 36 development program was the design of an accurate, wakeless, pattern-running underwater missile having the highest possible speed consistent with long range. Originally designed in early 1944 under an amended Mk 20 contract, Torpedo Mk 36 was an all-electric, submarine-launched, antisurface ship torpedo employing a motor of approximately 350 horsepower and a seawater-type primary battery. The General Electric Co., Pittsfield, Mass., and the Naval Torpedo Station, Newport, R.I., were responsible for its design. Between 1946 and 1950, further development of the Mk 36 torpedo was discontinued due to the development of Torpedo Mk 42.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	4000 pounds
Propulsion	Electric
Enabling	No
Guidance	Gyro
Homing	No
FC Settings	Mechanical
Warhead	Mk 36 800 pounds HBX-1
Exploder	Info not available

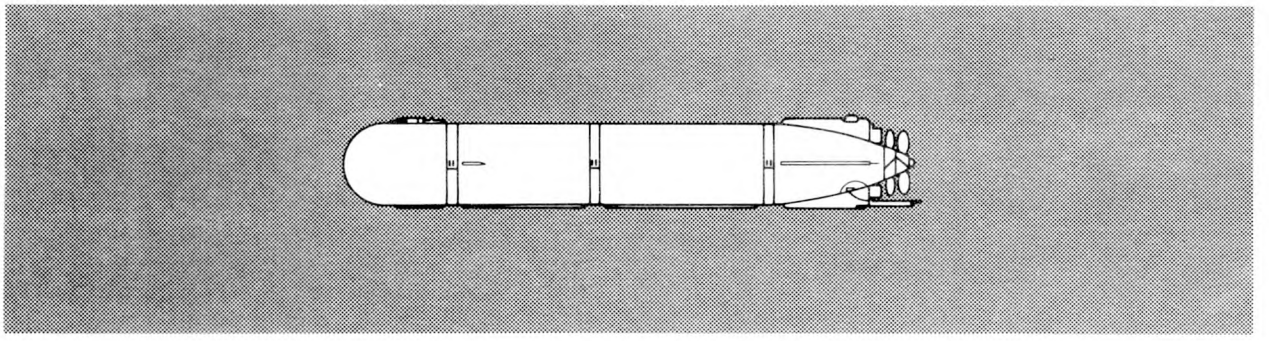
PERFORMANCE

Speed	47 knots
Range	7000 yards

Torpedo Mk37 Mods 0 and 3

DEVELOPMENT DATE:
1946

APPROXIMATE IN-SERVICE DATES:
1956 TO PRESENT



Torpedo Mk 37 is a two-speed, electrically-driven, active/passive acoustic homing torpedo. The main developers of the Mk 37 were Westinghouse Electric Corp., Sharon, Pa.; the Harvard Underwater Sound Laboratory, Cambridge, Mass.; and the Ordnance Research Laboratory of Pennsylvania State University. Engineering development of Torpedo Mk 37 began in 1946 but work had started in 1942 on the Project 4 panel (an echo-ranging, Doppler-enabled, acoustic homing system), which was incorporated into the Mk 37. The Mk 37 torpedo was produced in quantity by the Naval Ordnance Plant, Forest Park, Ill., and was the standard U.S. Navy submarine-launched, antisubmarine weapon for about 20 years. All Torpedoes Mk 37 Mod 0 have been withdrawn from the Fleet, refurbished, updated, and reissued to the Fleet as the Mod 3. Since the Mk 37 torpedo is available for foreign countries under the Military Assistance Program, however, some countries still maintain the Mod 0 version.

CHARACTERISTICS

PHYSICAL

Length	135 inches
Diameter	19 inches (21-inch guide rails)
Weight	1430 pounds
Propulsion	Electric motor
Enabling Range	300-9500 yards
Guidance	Gyro
Homing	Active, passive, combination
FC Settings	Electrical
Warhead	Mk 37 Mod 0 330 pounds HBX-3
Exploder	Mk 19 type Contact

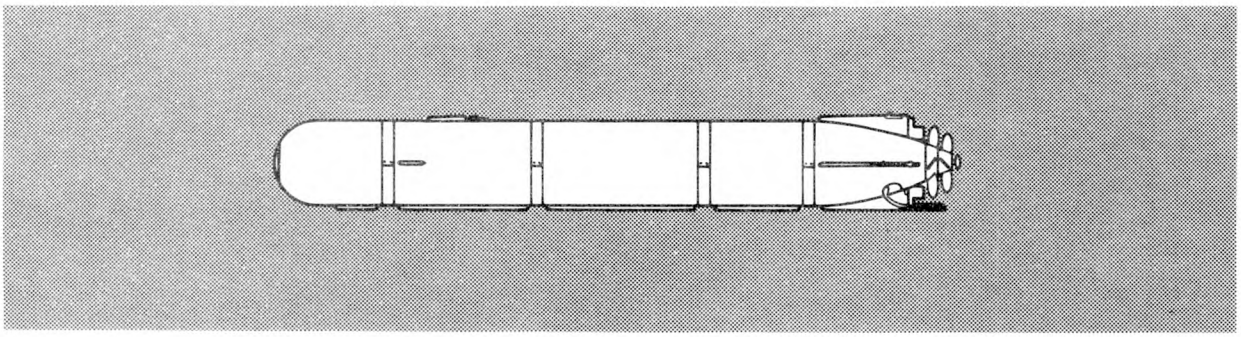
PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

Torpedo Mk37 Mods 1 and 2

DEVELOPMENT DATE:
1959

APPROXIMATE IN-SERVICE DATES:
1960 TO PRESENT



Torpedo Mk 37 (Mods 1 and 2) was a follow-on development of Torpedo Mk 37 Mod 0. This submarine-launched, antisubmarine weapon was developed by the Naval Underwater Ordnance Station, Newport, R.I., and the Vitro Co., Silver Springs, Md. The principal modification to the Mod 0 was the addition of a wire guidance capability. This wire guidance feature lengthened the torpedo by 26 inches and increased the weight by 260 pounds. In addition to the change to the torpedo, submarine fire control systems and torpedo tubes were also modified to provide the wire guidance capability. Torpedoes Mk 37 Mod 1, manufactured by the Naval Ordnance Plant, Forest Park, Ill., were refurbished and reissued to the Fleet as Mk 37 Mod 2 torpedoes. Under the Military Assistance Program, the Mod 1 version has been sold to foreign governments; only the Mod 2 version is still in use by the U.S. Navy.

CHARACTERISTICS

PHYSICAL

Length	161 inches
Diameter	19 inches (21-inch guide rails)
Weight	1690 pounds
Propulsion	Electric motor
Enabling Range	300-9500 yards
Guidance	Gyro-wire
Homing	Active, passive combination
FC Settings	Electrical
Warhead	Mk 37 Mod 0 330 pounds HBX-3
Exploder	Mk 19 Mod 1 Contact

PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

Torpedo Mk38 Mod 0

DEVELOPMENT DATE:
DEFERRED

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE

Torpedo Mk 38 was the designation given to a planned post-World War II antisurface ship, submarine-launched, acoustic homing torpedo intended to replace the Mk 28 torpedo. This development was postponed pending development and evaluation of Torpedo Mk 37. With the success of the Mk 37, development and subsequent evaluation plans for the Mk 38 were terminated.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	Info not available (≅ 3000 pounds)
Propulsion	Electric, primary battery
Enabling	Yes
Guidance	Gyro
Homing	Active, passive acoustic
FC Settings	Electrical
Warhead	Development deferred 600 pounds
Exploder	Info not available

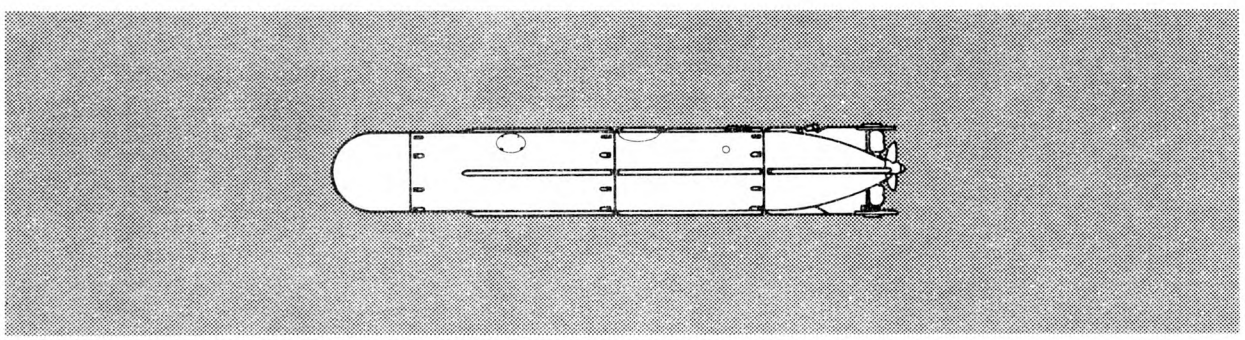
PERFORMANCE

Speed	35 knots
Range	10,000 yards

Torpedo Mk39 Mod 1

DEVELOPMENT DATE:
1946

APPROXIMATE IN-SERVICE DATES:
1946-1956



Torpedo Mk 39 Mod 1, developed by the Vitro Corp., Silver Springs, Md., and the Ordnance Research Laboratory at Pennsylvania State University, was the first torpedo to employ a trailing wire for mid-course guidance through the submarine fire control system. This torpedo was actually a Torpedo Mk 27 Mod 4 converted by the Philco Corp., Philadelphia, Pa., for Fleet familiarization and development of wire guidance techniques. The wire guidance feature was eventually incorporated into Torpedoes Mk 37 Mod 1 and Mk 45 which were issued for Fleet use. Because of this incorporation of wire guidance into other torpedoes, the Mk 39 submarine-launched, antisubmarine torpedo was considered obsolete and remaining units were scrapped.

CHARACTERISTICS

PHYSICAL

Length	133 inches
Diameter	19 inches
Weight	1275 pounds
Propulsion	Electric
Guidance	Wire
Enabling	Yes
Homing	Passive
FC Settings	Electrical
Warhead	Mk 39 Mod 0 130 pounds HBX
Exploder	Mk 19 Mod 10 Contact

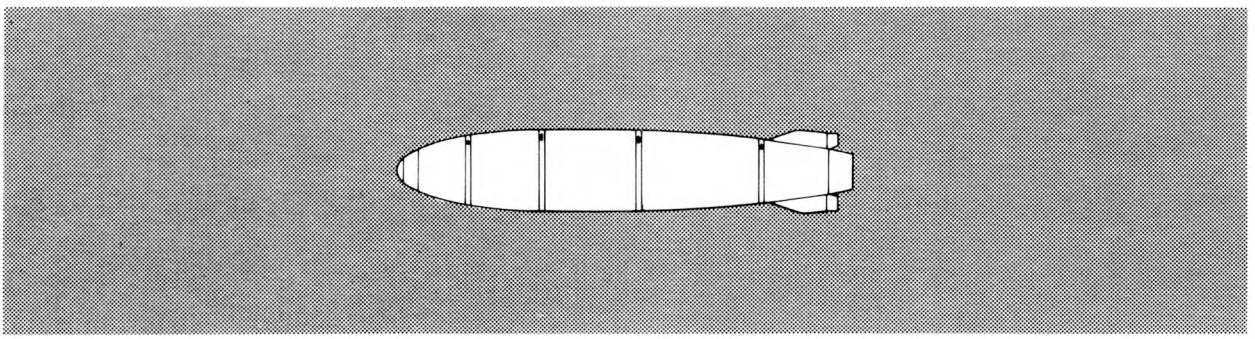
PERFORMANCE

Speed	15.5 knots
Range	13,000 yards/ 26 minutes

Torpedo Mk40 Test Vehicle

DEVELOPMENT DATE:
1946

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



Torpedo Mk 40 was the designation given to a proposed 1000-pound, aircraft- or guided missile-launched, antisurface ship torpedo, with a hydro-turbo jet or pump jet propulsion system. Work on this project confirmed German demonstrations that multibase solid propellants may be utilized to provide a gas supply (for short periods of time) at the pressures and temperatures found desirable for the application in question. The Torpedo Mk 40 developed by the Naval Ordnance Test Station, Pasadena, Calif., was discontinued due to technology limitations and to the emergence of Naval aircraft as an ASW platform rather than as a strike warfare torpedo platform.

CHARACTERISTICS

PHYSICAL

Length	105 inches
Diameter	21 inches
Weight	1250 pounds
Propulsion	Turbine, Lithium seawater
Enabling	No
Guidance	Gyro
Homing	No
FC Settings	Preset
Warhead	Mk 40 300 pounds HBX
Exploder	Info not available

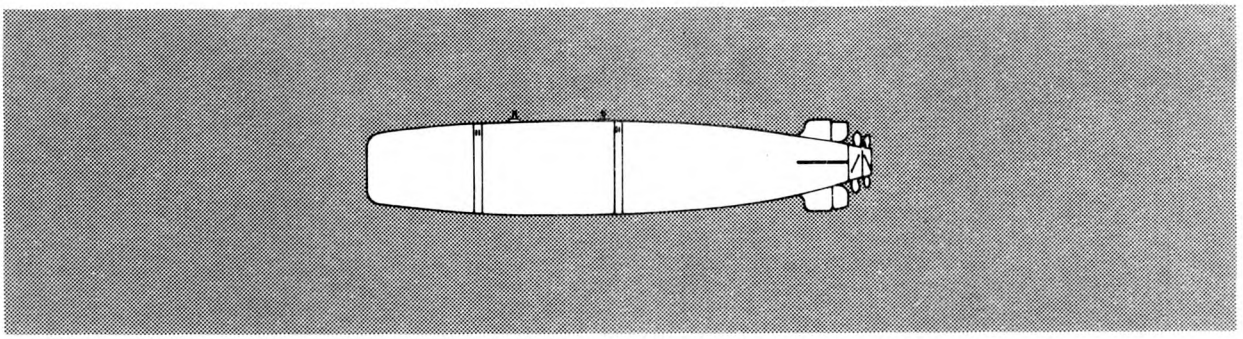
PERFORMANCE

Speed	80 knots
Range	2000 yards

Torpedo Mk41 Mod 0

DEVELOPMENT DATE:
1949

APPROXIMATE IN-SERVICE DATE:
NEVER IN SERVICE



Developed by the General Electric Co., Pittsfield Mass., as the antisubmarine, aircraft-launched version of the Torpedo Mk 35, the Mk 41 Mod 0 torpedo utilized the same homing system and the same type of propulsion as the Mk 35. The main difference between the Mk 35 and the Mk 41 was that functions unnecessary for aircraft launch were eliminated from the Mk 41. The Mk 41 unit was also made as compact as possible. Approximately 200 units were produced by G.E. for evaluation but production was discontinued in favor of the Mk 43 type torpedo.

CHARACTERISTICS

PHYSICAL

Length	120 inches
Diameter	21 inches
Weight	1327 pounds
Propulsion	Seawater battery
Enabling	No
Guidance	Helix search
Homing	Active, passive
FC Settings	Preset
Warhead	Mk 41
	150 pounds HBX
Exploder	Mk 19 type
	Contact

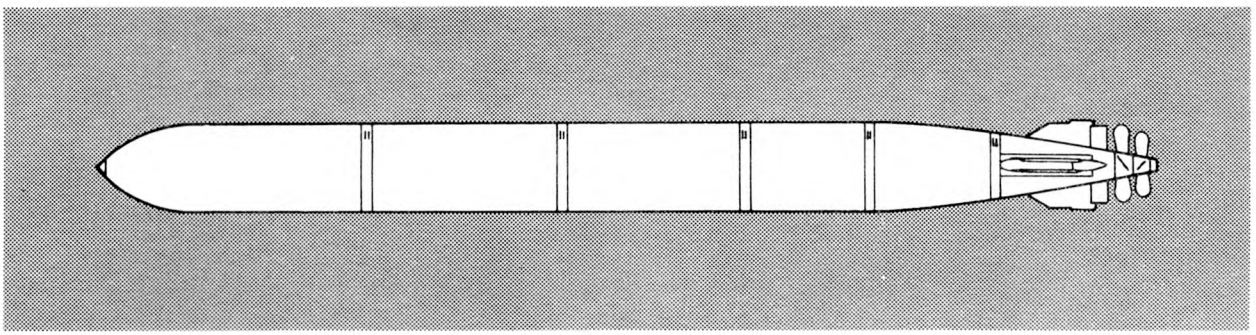
PERFORMANCE

Speed	25 knots
Range	8000 yards

Torpedo Mk42

DEVELOPMENT DATE:
1949

APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE



The Mk 42 torpedo was intended to be a submarine-launched, pattern-running, antisurface ship torpedo. In this development, an attempt was made to consolidate into one weapon past experience on the development of various torpedo components. Contributing to the development were the Naval Ordnance Test Station, Pasadena, Calif.; the Naval Ordnance Laboratory, Washington, D.C.; the Naval Torpedo Station, Newport, R.I.; the Ordnance Research Laboratory, Pennsylvania State University; and Stevens Institute of Technology, Hoboken, N.J. Torpedo Mk 42 development was terminated in 1952 with the intent of developing a pattern-running mod of Torpedo Mk 16.

CHARACTERISTICS

PHYSICAL

Length	246 inches
Diameter	21 inches
Weight	4000 pounds
Propulsion	Turbine
Enabling	Yes
Guidance	Gyro, pattern running
Homing	No
FC Settings	Electrical
Warhead	Mk 42 800 pounds HBX
Exploder	Mk 19 type IRXEO Influence

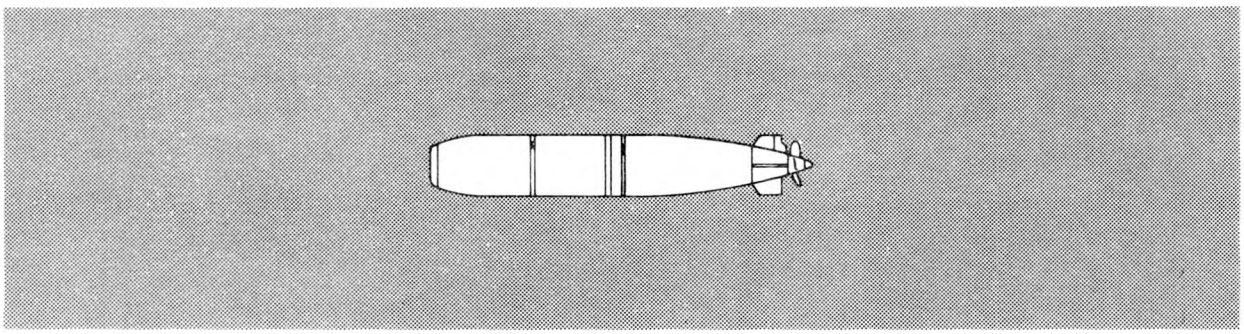
PERFORMANCE

Speed	40 knots
Range	20,000 yards

Torpedo Mk43 Mod 0

DEVELOPMENT DATE:
1950

APPROXIMATE IN-SERVICE DATES:
1951-1957



Torpedo Mk 43 Mod 0 was an aircraft-launched ASW torpedo. It was developed and produced by the General Electric Co., Pittsfield, Mass., to provide a lightweight, inexpensive torpedo for ASW use from fixed- and rotary-wing aircraft and airships. Approximately 500 of these torpedoes were manufactured for evaluation purposes but were discontinued in favor of Torpedo Mk 43 Mod 1.

CHARACTERISTICS

PHYSICAL

Length	88.25 inches
Diameter	12.75 inches
Weight	370.4 pounds
Propulsion	Electric
Enabling	No
Guidance	Helix search
Homing	Active acoustic
FC Setting	No
Warhead	Mk 43 Mod 0 60 pounds HBX
Exploder	Mk 19 type

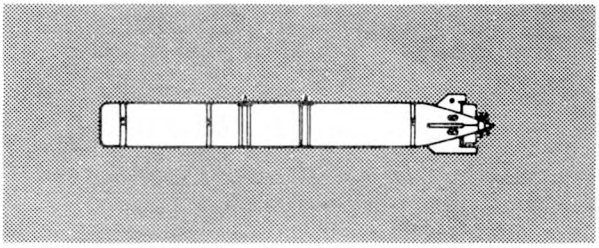
PERFORMANCE

Speed	20 knots
Range	4300 yards

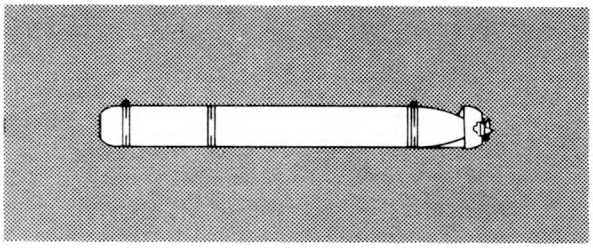
Torpedo Mk43

DEVELOPMENT DATE:
1950

APPROXIMATE IN-SERVICE DATES:
1951-1957



Mod 1



Mod 3

Torpedo Mk 43 Mods 1 and 3 were developed by Brush Development Co., Cleveland, Ohio, and the Naval Ordnance Test Station, Pasadena, Calif., during the post-World War II years. This was the first lightweight, antisubmarine torpedo capable of being launched by helicopters, fixed-wing aircraft, and surface ships. Approximately 5000 of these torpedoes were produced by the Brush Electronics Co., Cleveland, Ohio, and the Naval Ordnance Plant, Forest Park, Ill., from 1951 through 1959. This torpedo was withdrawn from Fleet use after the introduction of the Mk 44 torpedo.

Mod 1

CHARACTERISTICS

PHYSICAL

Length	91.5 inches
Diameter	10 inches (13.4 inches across fins)
Weight	260 pounds
Propulsion	Electric
Guidance	Helix search
Enabling	No
Homing	Active
FC Settings	No
Warhead	Mk 43 Mod 1 54 pounds HBX
Exploder	Mk 19 Mods 5 and 9 Contact

PERFORMANCE

Speed	15 knots
Range	9 minutes/ 4500 yards

Mod 3

PHYSICAL

Length	91.5 inches
Diameter	10 inches
Weight	265 pounds
Propulsion	Electric
Guidance	Helix search
Enabling	No
Homing	Active
FC Settings	No
Warhead	Mk 100 54 pounds HBX
Exploder	Mk 19 Mod 13 Contact

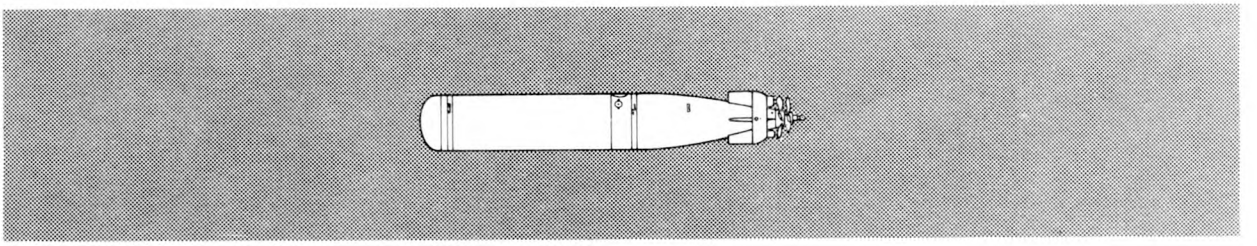
PERFORMANCE

Speed	21 knots
Range	6 minutes/4500 yards

Torpedo Mk44

DEVELOPMENT DATE:
1953

APPROXIMATE IN-SERVICE DATES:
1957-1967



Torpedo Mk 44 was a second-generation, lightweight ASW torpedo and the first service torpedo with a seawater-activated battery as a power source. This torpedo, the replacement for Torpedo Mk 43, had improvements in speed, warhead size, acoustic homing capabilities, and prelaunch-selectable search parameters. The Mk 44 was developed by the Naval Ordnance Test Station, Pasadena, Calif., and the Aeronautical and Ordnance Systems Division of the General Electric Co., Pittsfield, Mass. Production was started in 1957 at G.E., and in succeeding years at the Naval Ordnance Plant, Forest Park, Ill., and at the American Machine and Foundry Co., Buffalo, N.Y. Torpedo Mk 44 was used in service on U.S. destroyers and aircraft as an ASW weapon for about ten years until it was replaced by Torpedo Mk 46. In addition to being purchased by foreign governments under the Military Assistance Program, the Mk 44 torpedo was produced in Europe by NATO countries.

Mod 0

Mod 1

CHARACTERISTICS

PHYSICAL

Length	100 inches
Diameter	12.75 inches
Weight	425 pounds
Propulsion	Electric
Enabling	16-26 seconds
Guidance	Helix search
Homing	Active
FC Settings	Electrical
Warhead	Mk 101 Mod 0 75 pounds HBX-3
Exploder	Mk 19 Mod 12 Contact

PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

PHYSICAL

Length	101.3 inches
Diameter	12.75 inches
Weight	433 pounds
Propulsion	Electric motor
Enabling	16-26 seconds
Guidance	Helix search
Homing	Active
FC Settings	Electrical
Warhead	Mk 101 Mod 0 73 pounds HBX-3
Exploder	Mk 19 Mod 12 Contact

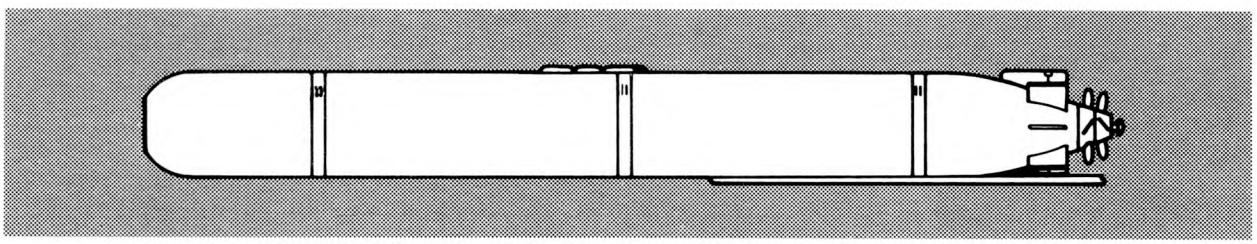
PERFORMANCE

Speed (knots)	Classified
Range (Yards)	Classified

Torpedo Mk45

DEVELOPMENT DATE:
1957

APPROXIMATE IN-SERVICE DATES:
1958-1976



Torpedo Mk 45 was a submarine-launched, antisubmarine, antisurface ship torpedo with wire guidance capabilities and a nuclear warhead. Using a seawater-activated battery as a power source, the torpedo was capable of high-speed, long-range, and deep-depth operation. Developed by the Applied Research Laboratory, University of Washington, Seattle, Wash., and the Westinghouse Electric Corp., Baltimore, Md., the Mk 45 torpedo was produced by Westinghouse starting in 1959. This torpedo, which was restricted to U.S. Navy use only, was phased out of service when Torpedo Mk 48 became available.

Mod 0

CHARACTERISTICS

PHYSICAL

Length	225 inches
Diameter	19 inches (21-inch guide rails)
Weight	2330 pounds
Propulsion	Electric
Enabling	No
Guidance	Gyro, wire
Homing	No
FC Settings	Electrical
Warhead	Mk 34 Nuclear
Exploder	Not applicable

PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified)

Mods 1 And 2

PHYSICAL

Length	227 inches
Diameter	19 inches (21-inch guide rails)
Weight	2213 pounds (unflooded)
Propulsion	Electric motor
Enabling Range	Fixed 2050 yards
Guidance	Gyro wire
Homing	No
FC Settings	Electrical
Warhead	Mk 102 Mod 0 Nuclear
Exploder	Not applicable

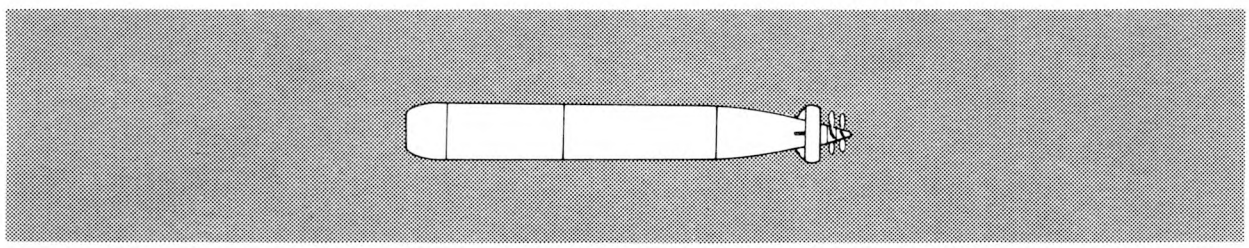
PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

Torpedo Mk46

DEVELOPMENT DATE:
1960

APPROXIMATE IN-SERVICE DATES:
1963 TO PRESENT



Developed by the Naval Ordnance Test Station, Pasadena, Calif., and Aerojet General, Azusa, Calif., the Mk 46 torpedo is a third-generation, lightweight ASW weapon. It is powered by a thermal piston engine and is capable of higher speed, longer range, better acoustic performance, and deeper depth operation than its predecessors. (Torpedo Mk 46 Mod 0 uses a solid propellant grain while the Mod 1 uses liquid monopropellant fuel. The Mod 1 performance in speed and range is better.) Torpedo Mk 46 production began at Aerojet General in 1963 and in the next two years production commenced at the Naval Ordnance Plant, Forest Park, Ill., and at Minneapolis Honeywell Inc., Hopkins, Minn. The Mk 46 torpedo is currently in service on U.S. Navy destroyers and aircraft and has been purchased by foreign governments under the Military Assistance Program. The torpedo will continue in service until replaced by a new generation lightweight ASW torpedo.

Mod 0

Mod 1

CHARACTERISTICS

PHYSICAL

Length	102 inches
Diameter	12.75 inches
Weight	568 pounds (dry weight)
Propulsion	Solid propellant/ piston engine
Enabling	Not applicable
Guidance	Laminar search
Homing	Active or passive/ active
FC Settings	Electrical
Warhead	Mk 103 Mod 0
Exploder	Mk 20 Mod 0

PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

PHYSICAL

Length	102 inches
Diameter	12.75 inches
Weight	508 pounds
Propulsion	Otto fuel/ Piston engine
Enabling	Not applicable
Guidance	Laminar search
Homing	Active or passive/ active
FC Settings	Electric
Warhead	Mk 103 Mod 0
Exploder	Mk 20 Mod 0

PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

Torpedo Mk47

DEVELOPMENT DATE:
1970

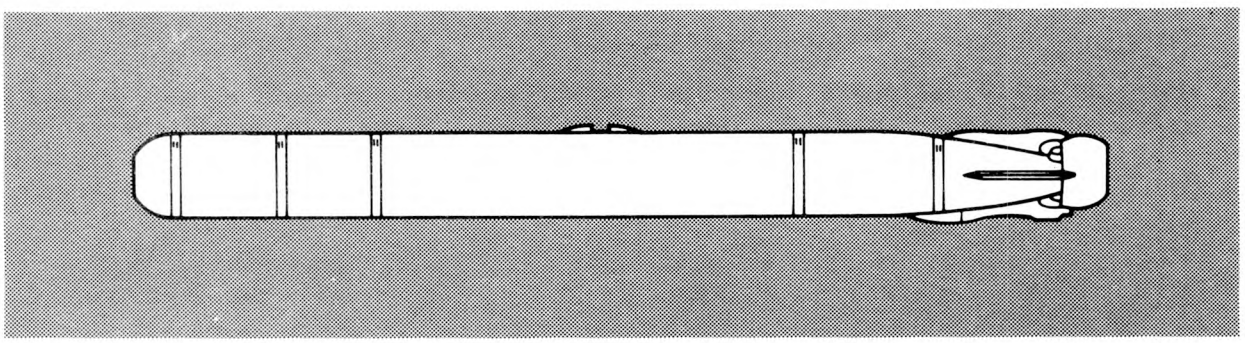
APPROXIMATE IN-SERVICE DATES:
NEVER IN SERVICE

Torpedo Mk 47 was the designation given a proposed antisurface, submarine-launched, high-speed torpedo. This torpedo was to have either thermal or electric propulsion. The development program was terminated before characteristics for the Mk 47 were fully defined due to the status of Torpedo Mk 48.

Torpedo Mk 48 Mod 1

DEVELOPMENT DATE:
1965

APPROXIMATE IN-SERVICE DATES:
1971 TO PRESENT



Torpedo Mk 48 is a long-range, high-speed, deep-depth, wire-guided, acoustic homing weapon used for detecting and attacking surface ships and fast, deep-diving submarines. The development of Torpedo Mk 48 Mod 0 grew out of the Navy's in-house Research Torpedo Configuration Program in 1963. Developed by the Applied Research Laboratory, Pennsylvania State University, and the Westinghouse Electric Corp., Baltimore, Md. (the prime contractor), this mod employed a turbine propulsion system. The end product of this development was redesignated Torpedo Mk 48 Mod 2. In 1967 Gould, Inc., Cleveland, Ohio (the prime contractor), and the Naval Surface Warfare Center, White Oak, Md., began developing Torpedo Mk 48 Mod 1. This version had a substantially redesigned acoustic homing system, and a piston engine was used for propulsion. After both the Mod 1 and Mod 2 Mk 48 torpedoes were evaluated, the Torpedo Mk 48 Mod 1 was selected for production at Gould, Inc., for ultimate Fleet use.

CHARACTERISTICS

PHYSICAL

Length	230 inches (max.)
Diameter	21 inches (max.)
Weight	3480 pounds
Propulsion	Positive displacement piston-type engine
Enabling	Yes
Guidance	Gyro, wire
Homing	Active, passive, combination acoustic
FC Settings	Electrical
Warhead	Mk 107
Exploder	Mk 21 Mod 0

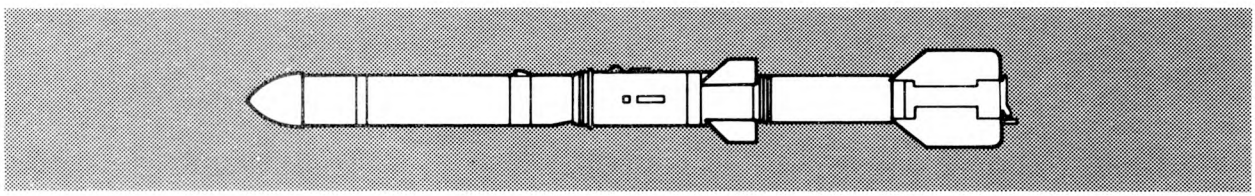
PERFORMANCE

Speed (knots)	Classified
Range (yards)	Classified

ASROC Missile

DEVELOPMENT DATE:
1956

APPROXIMATE IN-SERVICE DATES:
1962 TO PRESENT



The ASROC Missile is a solid fuel, rocket-propelled ballistic missile designed for standoff delivery from surface ships against submerged submarines. There are two basic missile configurations: (1) a rocket-thrown torpedo employing an acoustic homing torpedo as a payload, and (2) a rocket-thrown depth charge. In the torpedo configuration, the missile components are separated from the torpedo in flight and from that point, the torpedo enters the water and functions as though it was launched from an aircraft. The ASROC Missile is operational aboard cruisers, destroyers, and escort ships of the U.S. Navy. This missile was developed by the Naval Ordnance Test Station, Pasadena, Calif., and the Minneapolis Honeywell Regulator Co., Hopkins, Minn. There are many manufacturers of the ASROC since it is produced as individual components rather than as a complete unit. The components are then assembled into missiles by each issuing Navy activity.

Mod 3

CHARACTERISTICS

PHYSICAL

Length	180 inches
Diameter	
Airframe	13.25 inches
Fin Span	33.0 inches
Weight	949-957 pounds
Propulsion	Solid-propellant rocket motor
Enabling	Not applicable
Guidance	Ballistic
Homing	No
Payload	Torpedo Mk 44
Settings	Electrical
Warhead	Mk 101 Mod 0
Exploder	Mk 19 Mod 12 Contact

PERFORMANCE

Speed (knots)	Not applicable
Range (yards)	Classified

Mod 4

PHYSICAL

Length	177.43 inches
Diameter	
Airframe	13.25 inches
Fin Span	33.0 inches
Weight	1071-1073 pounds
Propulsion	Solid-propellant rocket motor
Enabling	Not applicable
Guidance	Ballistic
Homing	No
Payload	Torpedo Mk 46 FC
FC Settings	Electrical
Warhead	Mk 103 Mod 0
Exploder	Mk 20 Mod 0 Contact

PERFORMANCE

Speed (knots)	Not applicable
Range (yards)	Classified

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APPENDIX A

CHRONOLOGY OF SIGNIFICANT EVENTS

Date	Event	Page Number Where Discussed
1862-1866	Development and manufacture of the the first Whitehead Auto-mobile "Fish" Torpedo.	7
1869	U.S. Naval Torpedo Station, Newport, R.I., established. Intended to be an experimental station for the U.S. Navy for development of torpedoes, torpedo equipment, explosives and electrical equipment	9
1870	Development of the first U.S. Navy "Fish" Torpedo, USNTS, Newport, R.I.	9
1870	Royal Navy (U.K.) receives first delivery of Whitehead Torpedoes.	8
1870	Germany (Schwartzkopff) purchases rights to manufacture Whitehead Torpedoes.	8
1871	Royal Navy (U.K.) purchases manufacturing rights for Whitehead Torpedo.	8
1871	LCDR John Howell, U.S.N., granted Patent No. 121052 for Howell Torpedo.	17
1871	Rendel granted patent for counter-rotating propellers for torpedo propulsion.	20
1871	Test of first U.S.N. "Fish" Torpedo.	10
1873	A Lay Torpedo purchased by U.S. for experimental purposes.	
1874	Development of second U.S.N. "Fish" Torpedo.	10

Date	Event	Page Number Where Discussed
1874	Test of second U.S.N. "Fish" Torpedo.	10
1877	First Whitehead Torpedo ever fired against a hostile ship by HMS SHAH (U.K.) on Peruvian ironclad HUASCAR, in operation as a pirate. Unsuccessful, due to extreme range.	
1878	(Russo-Turkish War 1877-1878) Attack on Turkish ships by two Russian torpedo boats with Whitehead Torpedoes. Successful. Turkish revenue steamer INTIBAKH sunk.	
1880	Whitehead Torpedo, employing engine developed by Peter Brotherhood, Royal Laboratories, Woolrich, England, adopts counterrotating propellers and shaft exhaust.	20
1880	U.S.N. discontinues issue of towing torpedoes to ships.	
1886	U.S.N. purchases USS STILLETTO, prototype torpedo boat from Herreshoff, Bristol, R.I.	28
1888	Hotchkiss Ordnance Co., Providence, R.I., purchases manufacturing rights for Howell Torpedo.	61
1889	Hotchkiss receives order for 30 Howell Torpedoes for U.S.N. First U.S.N. quantity purchase of torpedoes.	61
1890	First U.S.N. torpedo boat, USS CUSHING, commissioned. Two 18-inch torpedo tubes installed.	28

Date	Event	Page Number Where Discussed
1890	First capital ship sunk by Whitehead Torpedo under wartime conditions -- Chilean battleship "BLANCO ENCALADA" -- 3500 tons.	19
1892	E. W. Bliss Co. negotiates manufacturing rights for U.S. manufacture of Whitehead Torpedo.	19
1892	U.S. Navy orders 100 Whitehead 3.55-meter Mk 1 torpedoes from E. W. Bliss Co.	19
1893	Trainable mounts installed on USS CUSHING torpedo tubes. Design attributed to Lt. F. F. Fletcher, U.S.N.	28
1894	L. Obry granted patent for steering gyro. Similar devices -- Kaselowski (Schwartzkopff), Petrovich (Whitehead).	19
1898	12 Schwartzkopff Torpedoes purchased by U.S.N.	21
1898	Development of Whitehead 5-meter Torpedo Mk 1 with gyro (Obry gear) control in azimuth.	19
1899	Development of Whitehead 5-meter Torpedo Mk 2.	20
1900	USS HOLLAND, first U.S.N. submarine to USNTS, Newport, R.I., for demonstration and test.	28
1901	USS HOLLAND operated by U.S. Navy crew from USNTS, Newport, R.I. successfully gained USS KEARSARGE (BB 5) without detection. Three Whitehead Torpedoes Mk 2 carried in HOLLAND.	28

Date	Event	Page Number Where Discussed
1901	Development of use of smokeless powder for impulse launching from surface tubes, USNTS, Newport, R.I.	
1901	Development of Whitehead hot-running Torpedo Mk 5 with three-speed/range adjustment.	21
1901	First U.S. Navy torpedo boat destroyer, USS BAINBRIDGE (DD 1) launched. Outfitted with two 18-inch torpedo tubes.	28
1904	Development of Bliss-Leavitt vertical turbine, hot-running Torpedo Mk 1 completed.	22
1904	Development of anticircular-run (ACR) device started at USNTS, Newport, R.I.	25
1905-1908	Development of Bliss-Leavitt Torpedoes Mk 2, Mk 3, and Mk 4; two-stage vertical turbine driven, hot-running.	22
1907	Construction of factory at USNTS, Newport, R.I.	25
1908	First order for torpedoes to USNTS, Newport, R.I. -- Whitehead Torpedoes Mk 5.	25
1900-1908	Austrian Capt. J. Giszetsky experiments with hot air device with water cooling.	
1910	Seaman Gunner rating in U.S. Navy replaced by Torpedoman rating.	

Date	Event	Page Number Where Discussed
1911	Development of Bliss-Leavitt Torpedo Mk 6 -- horizontal turbine driven.	26
1911	Development of Bliss-Leavitt Torpedo Mk 7 -- first steam torpedo.	26
1911	Development of Bliss-Leavitt Torpedo Mk 8 for use in destroyer standard 21-inch torpedo tube.	28
1914	ACR mechanism installed in warhead adopted.	25
1915	Development of Bliss-Leavitt Torpedo Mk 9 and Mk 10.	29
1915-1918	Development of Sperry Electric Torpedo (unsuccessful).	30
1917	USS CALDWELL (DD 69) first flush deck, four-stack destroyer with 12 21-inch torpedo tubes. First standard 21-inch torpedo tube installation.	28
1917	Development of type "D" torpedo -- Washington Navy Yard (Short Mk 7).	74
1917	Development of Jacoby torpedo (German Navy Electric).	30
1918-1919	R-class submarines commissioned R1(SS 78) - R20(SS 97). Standard 21-inch submerged torpedo tubes installed.	29
1919	Navy Experiment Station, New London, Conn., abandoned.	30

Date	Event	Page Number Where Discussed
1919	Development of type "EL" electric torpedo transferred from Navy Experiment Station, New London, Conn. to USNTS, Newport, R.I. -- Electric Torpedo Mk 1.	30
1918	Gould Island, R.I., acquired by U.S. Navy as high-explosive storage site.	
1920	Experimental torpedo launching from aircraft started at USNAS, Anacostia, D.C., with Torpedo Mk 7 Mod 5.	31
1921	Torpedo Station Air Detail established at Gould Island, R.I.	32
1922	Battleship use of torpedoes discontinued.	29
1922	All torpedoes of design prior to Torpedo Mk 7 condemned and withdrawn from service use.	31
1923	All torpedo work at locations other than Newport, R.I. terminated. (Washington Navy Yard; USNTS, Alexandria, Va.; and E. W. Bliss Co.)	30
1923-1926	Development of Torpedo Mk 11 started at Washington Navy Yard, completed by USNTS, Newport, R.I. Selectable three-speed capability. First all-Navy design.	31
1927	Air blowing exercise head developed.	
1928	Development of Torpedo Mk 12, USNTS, Newport, R.I.	31

Date	Event	Page Number Where Discussed
1930	Electric Torpedo Mk 1, type "EL" changed from 18-inch to 21-inch configuration.	
1931	Hammond radio-controlled torpedo patents purchased by BuOrd.	
1931	Electric Torpedo Mk 1, type "EL" development cancelled by BuOrd.	
1931	Development of Torpedo Mk 14 by USNTS, Newport, R.I.	34
1931-1937	Development of Torpedo Mk 13 and Mk 15 by USNTS, Newport, R.I.	34
1936	Use of torpedoes on cruisers discontinued.	
1940	Development of "Navol" Torpedo Mk 17 by USNTS, Newport, R.I.	39
1940	National Defense Research Committee (NDRC) established by President Roosevelt.	35
1941	Development of Electric Torpedo Mk 1 cancelled in 1938, reactivated by BuOrd as Electric Torpedo Mk 2 at USNTS, Newport, R.I.	30
1942	German G7e Electric Torpedo taken from captured "U 570."	35
1942	Development of Electric Torpedo Mk 18 -- Westinghouse Electric Corp., Sharon, Pa.	35

Date	Event	Page Number Where Discussed
1942	Development of Torpedo Mk 19, electric control version of Mk 18 -- Westinghouse Electric Corp., Sharon, Pa.	46
1942-1943	Development of Mine Mk 24 -- National Defense Research Committee/Bell Telephone Laboratory, Murray Hill, N.J. First acoustic homing ASW weapon.	36
1942-1943	Development of Mine Mk 30 -- Brush Development Co., Cleveland, Ohio. Parallel/backup development to Mine Mk 24.	36
1942-1945	Development of Torpedo Mk 32 -- General Electric Co., Pittsfield, Mass. First active acoustic torpedo.	38
1943	Electric Torpedo Mk 2 redesignated Torpedo Mk 20.	42
1943-1946	Development of Torpedo Mk 33 -- General Electric Co., Pittsfield, Mass./Bell Telephone Laboratories, Murray Hill, N.J. Aircraft/ submarine-launched acoustic torpedo.	47
1943	German homing Torpedoes T4 and T5 in operational use.	36
1943	Mine Mk 24 operational. Credited with sinking U 160, July 1943.	37
1943	Development of Torpedo Mk 27 Mod 0 -- Western Electric Co., Kearney, N.J. Submarine-launched version of Mine Mk 24.	37

Date	Event	Page Number Where Discussed
1943	Development of Torpedo Mk 16 ("Navol") -- USNTS, Newport, R.I.	41
1943-1946	Development of Torpedo Mk 25 -- National Research Defense Committee sponsored development of replacement for Torpedo Mk 13.	41
1943	Development of Torpedo Mk 21 Mod 0 -- Westinghouse Electric Corp., Sharon, Pa. Aircraft-launched, passive-homing, electric torpedo.	88
1943	Development of Torpedo Mk 23 -- USNTS, Newport, R.I. Single-speed (high) version of Torpedo Mk 14.	35
1943-1945	Development of Torpedo Mk 21 Mod 2 -- Ordnance Research Laboratory, Pennsylvania State University. Passive homing Torpedo Mk 13.	47
1944	Development of Torpedo Mk 22 -- Bell Telephone Laboratories, Murray Hill, N.J. Fixed-depth, active acoustic homing, electric torpedo.	47
1944	Development of Torpedo Mk 26 -- Westinghouse Electric Corp., Sharon, Pa. Seawater-activated battery.	46
1944	Development of Torpedo Mk 28 -- Westinghouse Electric Corp., Sharon, Pa. Passive homing, full-size electric.	38

Date	Event	Page Number Where Discussed
1944-1947	Development of Torpedo Mk 29 -- Westinghouse Electric Corp., Sharon, Pa. Improved Mk 28.	47
1944-1950	Development of Torpedo Mk 30 -- Ordnance Research Laboratory, Pennsylvania State. No torpedo -- investigation of wake homing as torpedo control system.	47
1944-1946	Torpedo Mk 31 development -- Harvard Underwater Sound Laboratory/ ORL, Pennsylvania State University. High-speed, acoustic homing version of Mk 18.	47
1944-1945	Development of Torpedo Mk 34 Mod 1 -- U.S. Mine Warfare Test Station, Solomons, Md. Two-speed Mine Mk 24.	48
1944-1952	Development of Torpedo Mk 35 -- General Electric Co., Pittsfield, Mass. Universal passive/active acoustic homing electric.	49
1945-1950	Development of Torpedo Mk 36 -- General Electric Co., Pittsfield, Mass. High-speed, long-range, nonhoming torpedo.	106
1946-1954	Development of Torpedo Mk 37 -- Westinghouse Electric Corp., Sharon, Pa. Active/passive acoustic, electric.	49
1946	Development of Torpedo Mk 27 Mod 4 -- ORL, Pennsylvania State University. Improved version of Torpedo Mk 27 Mod 0.	96

Date	Event	Page Number Where Discussed
1946	Development of Torpedo Mk 38 -- deferred due to development of Torpedo Mk 37.	109
1946-1951	Development of Torpedo Mk 39 -- Vitro Corp., Silver Spring, Md./ Naval Underwater Ordnance Station, Newport, R.I. Wire-guided (course correction after launch).	54
1946	Development of Torpedo Mk 40 -- Naval Ordnance Test Station, China Lake, Calif. High-speed aircraft torpedo.	111
1949-1950	Development of Torpedo Mk 41 -- General Electric Co., Pittsfield, Mass. Aircraft-launched version of Torpedo Mk 35.	49
1949-1952	Development of Torpedo Mk 42 -- multilab program. Pattern-running torpedo.	55
1950-1953	Development of Torpedo Mk 43 Mod 0 -- General Electric Co., Pittsfield, Mass. Lightweight, electric, ASW torpedo.	50
1950-1952	Reactivation of Torpedo Mk 32. Conversion to Torpedo Mk 32 Mod 2 -- Philco Corp., Philadelphia, Pa./NOTS, Pasadena, Calif. Active acoustic ASW torpedo.	102
1950-1952	Development of Torpedo Mk 43 Mod 1 -- Brush Development Co., Cleveland, Ohio. Lightweight electric, ASW torpedo.	50

Date	Event	Page Number Where Discussed
1953-1957	Development of Torpedo Mk 44 -- General Electric Co., Pittsfield, Mass. Second-generation, lightweight, ASW torpedo.	50
1953-1957	Development of Rocket Assisted Torpedo (RAT) -- NOTS, Pasadena, Calif. Rocket projected torpedo.	53
1956-1962	Development of Anti-Submarine Rocket System (ASROC) -- NOTS, Pasadena, Calif./Minneapolis-Honeywell Ordnance Division, Hopkins, Minn. Follow-on development of RAT.	53
1956	Development of Torpedo Mk 43 Mod 3 -- Clevite Research Corp., Cleveland, Ohio. Improved Mk 43 Mod 1.	115
1957	Development of Torpedo Mk 45 (ASTOR) -- Westinghouse Electric Corp., Baltimore, Md./Applied Physics Laboratory, University of Washington, Seattle, Wash. Electric, seawater-activated battery, nuclear warhead.	54
1960	Development of Torpedo Mk 46 -- Aerojet General Corp., Azusa, Calif./ NOTS, Pasadena, Calif. Third-generation, lightweight ASW torpedo.	51
1970	Torpedo Mk 47 proposed and cancelled due to Torpedo Mk 48.	56
1965-1974	Development of Torpedo Mk 48 -- Westinghouse Electric Corp., Baltimore, Md./Gould, Inc., Cleveland, Ohio. Advanced submarine-launched, acoustic, thermal propulsion.	56

APPENDIX B
IDENTITY INDEX

Throughout this report the identities of the participating activities are those which existed at the time of the particular event. Many changes have occurred in both the Naval establishment and industries. The following cross-reference list is provided to relate the former identities as noted in the report to the current identities where the change was radical. Intermediate changes in identities are omitted unless germaine to the report.

FORMER IDENTITY	CURRENT OR LAST KNOWN IDENTITY
Bureau of Ordnance (BuORD)	Naval Sea Systems Command (NAVSEA)
Sperry Gyroscope Co.	Sperry Division, General Dynamics Corp.
Navy Experiment Station, New London, Conn.	Disestablished - 1919
Naval Torpedo Station, Alexandria, Va.	Disestablished - Post-World War II
Naval Aviation Unit, Gould Island, R.I.	Disestablished - Post-World War II
Bureau of Aeronautics (BuAir)	Naval Air Systems Command (NAVAIR)
National Defense Research Committee (NDRC)	Disestablished - Post-World War II
Columbia University, Division of War Research	Naval Underwater Sound Lab. (NUSL), New London, Conn.
Harvard Underwater Sound Lab. (HUSL)	
Ship's Sonar	Naval Underwater Sound Lab. (NUSL), New London, Conn.
Torpedoes	Ordnance Research Lab. (ORL), Pennsylvania State College
Naval Underwater Sound Lab. (NUSL), New London, Conn.	Naval Underwater Systems Center (NUSC), New London (Conn.) Lab.
Ordnance Research Lab, (ORL), Pennsylvania State College	Applied Research Lab. (ARL), Pennsylvania State University
Naval Torpedo Station (NTS), Newport, R.I.	
Production	Naval Ordnance Plant (NOPF), Forest Park
Research and Development	Naval Underwater Ordnance Station (NUOS), Newport, R.I.

FORMER IDENTITY	CURRENT OR LAST KNOWN IDENTITY
Naval Ordnance Plant (NOPF), Forest Park	Disestablished - 1971
Naval Underwater Ordnance Station (NUOS), Newport, R.I.	Naval Underwater Systems Center (NUSC), Newport, (R.I.) Lab.
Naval Ordnance Test Station (NOTS), Pasadena, Calif.	Naval Ocean Systems Center (NOSC), San Diego, Calif.
Naval Ordnance Laboratory (NOL), White Oak, Md.	Naval Surface Weapons Center (NSWC), White Oak, Md.
Naval Mine Warfare Test Station, Solomons, Md.	Naval Coastal Systems Lab. (NCSL), Panama City, Fla.
Vitro Laboratories Inc., Silver Springs, Md.	Vitro Laboratories Division, Automation Industries, Inc., Silver Springs, Md.
Brush Development Co., Cleveland, Ohio	Clevite Division, Gould, Inc. Cleveland, Ohio